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ART. XIII.—*The Classification of Animals based on the principle of Cephalization;* by JAMES D. DANA.—No. III. *Classification of Herbivores.*[1]

THE principle of cephalization and its applications rest on the following simple facts:

(1.) An animal is embodied or concentred force, which force manifests polarity in the results of its action in development, that is, in the oppositeness of the anterior and posterior extremities of the structures evolved and also in the dorso-ventral relations of these structures.

(2.) The *primary* potential centre is in the head, or more precisely, in the cephalic nervous mass—an animal being fundamentally a cephalized organism. But, besides this, there may be one or more *secondary* centres.

(3.) Species differ (*a*) in the amount of force concentred; (*b*) in the degree of control of the systemic force over vegetative growth and development; (*c*) in the distribution of the force along the principal (or fore-and-aft) axis—that is, in its being concentrated mainly anteriorly, or diffused, to a greater or less degree, from the cephalic extremity posteriorly toward the caudal extremity or pole.

(4.) The differences just mentioned are expressed in the structure of the organism; and all such expressions are necessarily expressions of grade.

(5.) Each of these kinds of differences must have expression, or, be apparent, (*a*) through the various circumstances attending

[1] For Article I, see the last volume of this Journal (vol. xxxvi), pp. 315, 440; and for Article II, this volume, p. 10.

development or growth, and (*b*) through all the steps in the progress of growth, as well as (*c*) in the resulting structures.

The above general facts are at the foundation of all the methods of cephalization, or decephalization, pointed out in Article I. They receive further illustration in the pages beyond, and special explanations on pages 175 to 182.

This subject of cephalization throws new light, as has been shown, on the limits and gradal distinctions of groups. The characteristics which it affords, like all others appealed to in classification, cannot overrule affinities based on obvious resemblances in type of structure. Their object or use, on the contrary, is rather to exhibit the affiliations and distinctions of types by presenting new views of their relations and making manifest the true basis of all affinities. Between different types of structure there is generally a difference of grade, which is evinced in characters that indicate different degrees of cephalization.

It follows from the nature of the principle that both high and low cephalization, although *opposites*, should often lead to *similar* results; as, for example, to abbreviations anteriorly and posteriorly in animals generally—to memberless abdomens in Crustaceans—to small wings in Insects, etc. (Art. I, pp. 337, 440). This evolving of approximately like results from the opposite extremes of cephalization is one source of the difficulties in the subject of classification. But the law cannot, on account of the trouble it may give, be condemned; for, as I have before remarked, it is in accordance with universal truth that smallness, or circumferential contraction, should proceed both from concentration, and from lack of quantity, although these are opposite conditions. The difficulties in the way of a right use of the principle of cephalization are, therefore, in nature, and must be met by the only legitimate means—thorough study.

Many errors in the attempts to present to view the system of nature have arisen from confounding cases that, as above explained, are widely diverse. The writer would not claim to be always right in his own interpretations; for he is well aware that far profounder knowledge is requisite for unfailing accuracy. But he believes that the principle appealed to is right and fundamental; and if he ventures to present new classifications of departments in zoology in which adepts in these departments have made trials with different results, it is only to offer such illustrations of the principle in view as will serve to exhibit the methods of its application and its various bearings.

In the first article on this subject, after explanations of the general subject of cephalization, the higher subdivisions of the animal kingdom were considered. In the second, one of the *Orders* was reviewed and an arrangement given of its subdivisions, down to the grade of Tribes. In the present, the classification of a *Tribe* is followed out, down to the grade of Families.

Classification of Herbivores.

Under the order of Megasthenes,[3] the tribe of Quadrumanes, as stated on p. 334, Art. I, is properly *hypertypic*, that of Carnivores *superior typical*, that of Herbivores *inferior typical*, and that of Mutilates (or Cetaceans) *hypotypic*.

1. *Distinctions between Herbivores and the tribes next superior and inferior.*

A. Herbivores show their inferiority to Carnivores, or the superior typical group of megasthenic Mammals, on the basis of the principle of cephalization, in the following ways:

(1.) In the fore-limbs being defunctionated of the power of prehension and reduced to simple locomotive organs.

(2.) In the fore-limbs being not as much superior to the hind-limbs in strength as in the Carnivores, and even inferior to the hind-limbs in some species,—Herbivores, being less strongly *prosthenic* than Carnivores, and the species of the larger and most characteristic group being *metasthenic*.

(3.) In the structure being strongly amplificate.—Taking the Lion as the standard of size for the highest grade of life among typical Megasthenes, the Elephant—certainly inferior in type, and, therefore, also in degree or quality of systemic force—exhibits inferiority likewise in its great bulk; it is a marked example of a *gross-amplificate* structure. Hogs and the related species are no less gross-amplificate, but on a feebler life-system. Again, the Horse and also all Ruminants are *long-amplificate*, as appears strikingly in their lengthened limbs, especially the extremities of the limbs, and, also, in the neck and body.

(4.) In the head being prolonged or amplificate.—Even the Elephant is here no exception; for the great tusks and trunk correspond to an elongation of the head extremity, their development being at the expense of the jaws and of part of the teeth. In the Horse, the facial part of the skull is four times as long as the cranial portion. (See p. 165.)

[3] In order that the position of Herbivores, as recognized by the writer, may be clearly understood by the reader, I repeat here the arrangement of the higher divisions of Mammals proposed in the number of this Journal for January, 1863, (vol. xxxv, p. 65), presenting the tribes of Megasthenes and Microsthenes, as before, in parallel columns in order to exhibit their parallel relations.

Order I. Man.

Order II. Megasthenes.	Order III. Microsthenes.
1. Quadrumanes.	1. Chiropters or Bats.
2. Carnivores.	2. Insectivores.
3. Herbivores.	3. Rodents.
4. Mutilates.	4. Edentates.

Order IV. Oörocoids.

Marsupials and Monotremes.

(7.) In the extremely wide variations as to size and shape under the type, and the occurrence of bizarre features.—As, for example, (1) in the existence of horns on the forehead or nose; (2) in the nose being prolonged into a proboscis; (3) in the teeth being sometimes elongated into tusks which have the size and function of horns, and might be called *jaw-horns;* (4) in the limbs and neck having sometimes extravagant length; (5) in abnormal growths on the body, as in the hump of the Camel and the Brahmin Ox, the dewlaps of Oxen, etc.

(8.) In the forehead, in very many species, being perverted to serve for defense or attack; and the nose sometimes for prehension, digging, etc., as well as defense.

(9.) In the typical species being elliptic as regards one or more of the four types of teeth in one jaw or both, this deficiency in the dental series being a characteristic of the type; also in a void interval in the series of teeth between the molars and canines in the same typical species.

(10.) In being prematurative in development, the young animal having the power of sight and locomotion almost as soon as born.

The abnormal outgrowths from the body or skeleton of Herbivores—as of horns on the forehead or nose, of a proboscis by an elongation of the nose, of tusks, horn-like in function, by an elongation of teeth, of humps of fat as in the Camel—serve to show, and even, if possible, more strikingly than the tendency to amplificate structures, that the vegetative force in Herbivores is far less under systemic control than in Carnivores. The Carnivores may be styled a *tight* type, the Herbivores remarkably a *loose* one. Stepping over the line from Carnivores to Herbivores is passing from a group of marked regularity to one full of abnormities.

B.—The superiority of the urosthenic aquatic Herbivores (Sirenians) to the Mutilates (Cetaceans) is exhibited in their—

(1.) Having the nostrils never defunctionated, nor perverted to blowholes, these organs being essentially like those of terrestrial Mammals.

(2.) Never being multiplicate as to the number of phalanges, or joints, of the digits.

(3.) Never being multiplicate as to the teeth.

(4.) Never being so elementalized as to the teeth that the distinction into the different types (molars, etc.) is lost (Mutilates, like Reptiles, having the teeth all of a kind).

(5.) Having the *primary* potential centre (p. 157) never abnormally remote from the anterior extremity.

Some species of Cetaceans (Balænæ and Physeters) have, like the Limulus among Crustaceans, one-third to one-half of the length of the body anterior to the base of the jaws, so that

the primary centre (or that of the brain) is very remote from the anterior extremity—thus approximating to the position it has in the Radiates, and showing a low grade of decephalization. See on this point, Art. I, p. 328, and beyond, p. 179.

Mutilates consequently differ from aquatic Herbivores fundamentally in (*a*) being *multiplicate* structures, as manifested in their limbs and teeth, as well as in the less important fact of great length of body behind; and also (*b*) in being more *elementalized* structures, as shown in the reptile-like teeth. The type is eminently, therefore, a multiplicate and elementalized type, and thus stands apart from that of the Sirenians.[3]

2. *Prosthenic, metasthenic and urosthenic distinctions among Herbivores.*—The distinctions, *prosthenic, metasthenic* and *urosthenic* appear to be an important basis of subdivisions under the Herbivorous type.

The *urosthenic* species (or those using the caudal extremity for locomotion) are the *Sirenians*, as the Dugong and Manatus.

The distinction of *prosthenic* and *metasthenic* is manifested among the other Herbivores in two ways: (1) a higher or *primary*, in the general structure; and (2) an inferior or *secondary*, in the extremities of the limbs.

(1.) *In the general structure.*—Under this method, the *prosthenic* species are those in which the fore-limbs are the stronger pair, and the *metasthenic*, those in which the hind-limbs are the stronger. The *former* include the Proboscideans, Rhinoceroses, Tapirs, Hogs and Hippopotamids. The Hog is particularly strong in the neck and fore-quarters. It is well known that a fatted hog often loses the use of its hind-limbs from overgrowth, and not of the fore-limbs, although the fore-limbs carry not only their share of a body nearly equally divided between the limbs, but also the heavily weighted head.

The *metasthenic* species are the Solipeds and the Ruminants, in which the hind-limbs are well known to be the strong pair. The Horse and Camelopard use their hind-limbs for self-defense, and so do also, to some extent, many of the Ruminants. Among the large Mammals, strength in the posterior limbs is an essential requisite for a draught-animal; and not less so for a mountain-climber, especially when the fore-limbs are not prehensile; and, consequently, nearly all the larger mountain-climbing animals, frequenting precipitous heights, are species of Ruminants.[4]

[3] This definition excludes not only the Sirenians but also the Zeuglodonts, which have been shown to be Carnivores, with normal teeth and nostrils, although very elongate in body and *urosthenic*.

[4] For a draught-animal something more is needed than mere strength of hind-limbs, and consequently all of these metasthenic species are not good for this kind of service. There may be too great length of limb,—too little real strength for the long and steady pull which it requires, and which is very different from the mere

Such species, strong in the hind-limbs, are well named *Sthenomeres* (from the Greek σθενος *strong* and μηρος *thigh*).

(2.) *In the extremities of the limbs.*—The sthenic distinction referred to under this head is the inferior of the two because it appears only in the *extremities* of those organs which in their general relations exhibit the former. The manifestation of it is confined to the hand and foot.

As the inner side of the hand or foot is the more central side in the system and the outer the more circumferential—a fact which any one will become aware of on looking at his open hand as it lies on a table—the higher species should have the principal strength in the inner fingers rather than the outer. The transfer of force from the innermost to the outer, with descending grade of species, is well exemplified among Herbivores and the higher Mammals.

In Man the *inner* toe is the strongest, and the order of strength is that of the toes, or 1, 2, 3, 4, 5. It is the same also in the hand. In the Gorilla it is the same for the foot, and for the hand there is only this difference that 1 and 2 are about equal. In the inferior Quadrumanes and the superior Carnivores the *third* is the strongest as well as largest digit, and in many Carnivores the first in the hinder pair is obsolescent. In the inferior Carnivores, as the Plantigrades, the *third* and *fourth* digits are often about equal, and the *fifth* as strong as the *second:* thus in *Ursus Americanus* (as figured in Blainville's *Osteologie*) 4=3, and 5=2; in *U. arctos* (*ferox*) 2, 3, 4, 5 are very nearly equal; in *U. labiatus* 4 and 5 are *the longest*, exceeding 3; in species of *Nasua* 4=3 and 5=2; in the *Cercoleptes* or kinkajou, one of the lowest of Carnivores, 4 *is a little longer than* 3 and 5 *than* 2; in *Gulo luscus* 4=3; in the Mustelids, *Lutra vulgaris* and *Mustela Foina*, 4=3, or 3 is scarcely the longer; in the Viverrids 3 is generally slightly longer than 4, but in the inferior aberrant species *Eupleres Goudotii* and *Bassaris astula* 4=3 and 5=2. These species are therefore essentially *paridigitate*, except that the first digit is present. Thus there is an outward diffusion of force in descending from Man to the lower Carnivores.

Under Herbivores, the higher species have the *third* toe the longest—or, they are *imparidigitate*, as these kinds are usually styled. Thus it is with the Proboscideans, Rhinoceroses and Tapirs, and it is so *whether the number of toes be three or four*, that is whether *even or odd in number*.

In the inferior Herbivores the force is still more circumferentially diffused; for the *fourth* digit is equal to, and sometimes

movement of the legs demanded of a beast of burden,—too little superiority in the posterior to the anterior limbs, or an ill-adjustment of muscles and lungs, etc., for the purpose. The Camel, one of the hypotypic or degradational Ruminants, is a case here included.

even stronger than, the *third;* and, at the same time, the *fifth* is as strong as, or stronger than, the *second*, if both are not altogether wanting; while the *first* is obsolete. The examples include all the so-called *paradigitate* species, as the Hog, Stag, Ox, etc., in which the toes are equal (or approximately so) in pairs, the larger pair consisting of the *third* and *fourth* toes, and the other, of the *second* and *fifth*. In the common Ox, the *fourth* toe appears to exceed slightly the *third* in size, and so also, the rudimentary *fifth* the *second*. In the Hog, also, the *fourth* toe is sometimes a little the largest.

This sthenic distinction partially fails among degradational forms, such as the Seals, Sirenians and Cetaceans, in which the structure is so far degenerated that this delicate mark of grade has not its full normal exhibition.

3. *Distinction depending on the existence, or not, of a power-organ to aid in feeding, additional to those of the jaws.*—Carnivores have, as one of their characteristics, organs apart from the teeth to aid in seizing or gathering their food. Among Herbivores, the Elephant has an organ of prehension of great power and perfection in the trunk or elongated nose. The Tapirs and Hogs have also an elongated nose, which, although incapable of prehension, except to a slight degree in the former, is a power-organ essential to the animal for the collection of its food. The Rhinoceros has a nose-horn serving in the same way. The nose is thus in all these groups, from the Elephant to the lowest of the Suids or Hog-group, not merely a nose, but an organ of special power and use for obtaining the food of the animal; and the species might be described in a word as *Sthenorhines* (from the Greek *σθενος strong* and *ῥις nose*).

The Horses and the Ruminants feed themselves by grazing, using their lips, teeth and tongue for the purpose, but having no aid from the nose.

4. *Distinction of gross-amplificate and long-amplificate.*—*Gross-amplification* consists in a general enlargement of the structure beyond the type-size for a given amount of systemic force, and does not necessarily imply a change in the relative sizes of the parts, or in their proportions. It may be manifested both in the skeleton and in its fleshy covering; and when in the latter it is often apparent in the production of an abnormal amount of fat over the body. This fatty overgrowth is the lowest grade of gross-amplification.

Long-amplification is exhibited in an increased proportional length of the body and its limbs or members, involving in Vertebrates an elongation of the bony structure.

The *gross-amplificate* terrestrial Herbivores are those of the Elephant, Tapir and Hog groups, in which there is little difference in the proportions of the body from those of the Carnivores.

The *humerus*, for example, bears approximately the same proportion in length to the *radius* and to the whole limb, and also to the neck, in the Elephant, Rhinoceros, Hog and Hippopotamus as it does in the Carnivore. The length of head is increased in each of these groups by an amplificate snout—as remarked on the preceding page; but this is in part a *fleshy* elongation; and it is sometimes increased also by means of a horn, but only an *epidermic* horn. The bony-structure of the head has an elongation beyond that characteristic of the lower Carnivores; but it is independent of any in the limbs.

The Bovine species are examples of gross-amplification on a *long-amplificate* structure.

The *long-amplificate* species include all the Ruminants, together with the Solipeds or species of the Horse-family among the Non-ruminants.

This long-amplification is exhibited prominently in the *limbs*, *neck* and *head*.

(1.) *In the limbs.*—As in other cases, it is manifested most strikingly toward the circumferential limits of the system. The humerus shows no elongation, and is often even shorter, as compared with the size of the body, in these amplificate species than in more typical kinds. Below the humerus, amplification is apparent in the fact that the radius exceeds in length the humerus; it is still more manifest in the great elongation of the bones below, especially the metacarpals and phalanges, the former alone being sometimes as long as the radius. The same general facts are true of the hind-limb. Owing to this extension of the extremities, the joint which seems like the knee in the leg of a Horse, Deer, Ox, etc. is really the commencement of the foot. In the fore-limb of a Horse, the humerus is hardly *one-fourth* the whole length of the limb; the radius is nearly *a fourth* longer than the humerus; and the cannon-bone is *two-thirds* as long as the radius. In the Camel the proportions are not very different; the radius is relatively a little longer, and the cannon-bone as much shorter. In the Camelopard the humerus is but a little more than *one-fifth* of the whole limb (measured, as in the Horse, from the commencement of the humerus to the extremity of the digits); the radius is *one-half* longer than the humerus; and the cannon-bone, or metacarpal, is *as long as* the radius. The facts strongly contrast with those among the Elephant, Tapir and Hog groups, the humerus in these species being between *one-third* and *four-ninths* of the length of the whole limb, and longer than the radius.

It would seem, therefore, that *the length of the humerus in the long-amplificate species may be taken as an approximate indication of the true type-size, or as a standard from which to measure the degree of amplification of the structure.* Still, I see no positive

proof that the humerus is not here shortened in compensation for the lengthening below.

(2.) *In the neck.*—No one will question the fact of a long-amplification of the neck and head in these species. It is however difficult to find a proper standard of length for definite comparisons. There is some special interest in the relations to the length of the humerus, and I therefore mention these relations, as has been done in the comparisons between the parts of the limbs.

In the species of Felis, the neck is not longer than the humerus; in the gross-amplificate Herbivores, as the Rhinoceros, and Hippopotamus, the same is true; but in the long-amplificate species, a very different relation exists. In the Horse the neck is *twice* the length of the humerus; in the Camel nearly *three times;* in the Camelopard over *three times.*

(3.) *In the head.*—The outer or more circumferential portion of the jaws, corresponding to the incisors and canines, pushes out, under this amplification, far away from the more basal or molar portion, making the void space between quite wide, much wider than in the Rhinoceros and Tapir. Referring to the humerus as a standard of length, as above, the cranium in the genus Felis, measured from the extremity of the jaws to the occiput, is from *four-fifths* to *once* this unit; in the Rhinoceros, *one and one-fourth*, to *one and one-third;* in the Horse, nearly *twice;* in the Camel, *one and one-third;* in the Camelopard, *one and a half.* The ratio for the Camelopard and Camel does not exhibit the true condition, because both species are cephalically vastly inferior animals to the horse and therefore have unusually small heads for the size of the animal. The Camelopard shows the long-amplification of its head in the narrow proportion of the skull, and the long void space in the jaws. This aberrant Ruminant is built, not only in its long legs and neck but also in its little elongate head, on the type of a Grallatorial or Wading bird.

This amplification or circumferential extension of the head appears in many species to be concurrent with that in the limbs, as if the two were of like dynamical origin, or had a dependent genetic relation in the structure.

Long-amplification in the head is still further exhibited in the typical Ruminants through an outgrowth of horns on the forehead. This is a frontal elongation, bony in its nature (or having a bony core at least), and peculiar to these *long-amplificate* species. In other words, those species in which the bones of the limbs grow long have generally long growths of horn from the forehead.

5. *Subdivisions in the classification of Herbivores.*—The distinctions which have been mentioned on the preceding pages point to the same general arrangement of the terrestrial Herbivores.

Two grand divisions are indicated.

I. The *Elephant*, *Tapir* and *Hog* groups are alike in being—

(1.) Prosthenic in general structure.

(2.) Gross-amplificate; rarely long-amplificate in the limbs.

(3.) Not amplificate in the forehead through an outgrowth of bony horns—the only horns being nasal, and these epidermic.

(4.) Amplificate in the snout, there being, in addition to the anterior elongation of the cranium, a fleshy elongation, or sometimes an epidermic horn.

(5.) STHENORHINES, the elongate snout being a power-organ for aid in feeding, etc.

II. The *Solipeds* and *Ruminants*, on the contrary, are—

(1.) Metasthenic in general structure, and, therefore, STHENOMERES.

(2.) Long-amplificate in the limbs, neck and head, and sometimes, *in addition*, gross-amplificate.

(3.) Long-amplificate in the forehead through an outgrowth of horns, except in the superior group of Solipeds and the inferior or hypotypic species.

(4.) Not amplificate in the fleshy part of the snout.

(5.) Not Sthenorhines—having no use for the nose but the legitimate one.

The two groups are then—

I. The Prosthenics, or STHENORHINES, including the Elephant, Tapir and Hog groups.

II. The Metasthenics, or STHENOMERES, including the Solipeds and Ruminants.

The species of the Hog-group and Tapir-group are closely related, in general form; in their short limbs; in the long and powerful and, thereby, *working* snout; in their teeth approximating to those of the Carnivores; and in the omnivorous character or tendency of some species. And the relation of the Tapirs to the Elephant-group is no less striking. These affiliations have been generally admitted by zoologists. The species of the Tapir and Hog groups, especially the latter, are the most Carnivore-like of Herbivores.

So, among the Sthenomeres, the living Ruminants have by all been associated in classification. The Solipeds alone have been arranged in most systems with the Pachyderms. But these are metasthenic like the Ruminants, being the strongest of Sthenomeres and the most valuable of draught-animals; they are grazing animals, like the Ruminants, and have no rooting nose; they have the same great length to the void interval on the jaw between the molar and the other teeth; and they have similar long-amplificate limbs. While, then, the Horse has undeniable

relations to the Pachyderms, it has close affinities also to the Ruminants. It is a *Sthenomere* and not a Sthenorhine; but it stands in the group of Sthenomeres, between the Ruminants and the Sthenorhines,[8] representing a Pachydermatoid division in the group.

The prosthenic species, it appears, are the *gross-amplificate*, and the metasthenic are the *long-amplificate*. But this distinction in amplification is not of that fundamental nature which would lead to its being an exclusive feature of either type; and yet the exceptions to its being so are remarkably few. In the *gross-amplificate* group, or that of the *Sthenorhines*, the *Macrauchenia*, if a Tapiridean (see p. 172), is one exception—the species having, according to Owen, a long neck, nearly as in the Llamas. The extinct *Paleotheres* are other exceptions; for in these Eocene associates of the Anoplotheres the metacarpals and metatarsals have about the elongation of those of the *Anoplotheres*. All the long-amplificate Sthenorhines are *extinct species* (p. 183).

The distinction of prosthenic and metasthenic observed in the *extremities* of the limbs, or the digits, which has given rise to the subdivision into *Imparidigitates* and *Paridigitates*, affords an indication of grade *under* the above two grand divisions—the paridigitate species being the inferior. Thus the Hog-group (paridigitate) stands below the Tapir-group (imparidigitate), and is, hence, at the foot of the *Sthenorhines;* and the Horse-group (imparidigitate) is at the head of the *Sthenomeres*. As this distinction is inferior in sthenic value to that of prosthenic and metasthenic manifested in the general structure (pp. 161, 162), it cannot properly be made the basis of the *principal* grand divisions of Herbivores, as proposed by Owen, unless all such sthenic characters are overruled by fundamental resemblances in type, which is here not the case; the type-resemblances bear the other way, and not to a separation of the Hogs and Tapirs, nor to a union in one group of the Hogs and Ruminants.

The existence in Paridigitates of two horns, one either side of the front, is mentioned by Owen as an example of *pairs* in these species, additional to that in the toes; and the occurrence in the Imparidigitates of a horn (or horns) only on the medial line of the front as an additional case in these Herbivores of an *odd* organ. This *odd* horn occurs only in the Rhinoceroses among the Imparidigitates, and on a *medial* organ, the nose; and with so small a range of facts to sustain the deduction, we may reasonably doubt the alleged connection between the odd or

[8] It may also be here repeated that the Horse is related to the Ruminants in not having a *decidua* developed,—a *decidua*, as stated by Huxley, characterizing the higher Megasthenes, from Man through the Quadrumanes and Carnivores to the higher Herbivores (the Elephant and Hyrax, at least); but not the species of the Hog-group, the lowest of Sthenorhines, nor any of the Sthenomeres. (See Art. II, p. 13).

even in horns and the odd or even in the toes. The true distinction with regard to the horns appears to be that already mentioned:—that the Sthenorhines have only the *nose*—not the forehead—elongated or amplificated through a growth of horns, and this is an epidermic amplification, while among the Sthenomeres, an inferior group, the bony structure of the *forehead* is long-amplificate.

If it be sustained that the Camelopard has a central horn on the front of the head, as has been claimed and recently reaffirmed, a case of an odd or medial horn occurs among the *Paridigitates;* but it is a forehead-horn.

We should therefore make the statement thus:

The Sthenorhines, *gross*-amplificate species, may have one or two *nasal epidermic* horns, or *horns proceeding from the exoskeleton.*

The Sthenomeres, *long*-amplificate species, may have two or more *frontal bony* horns, or *horns proceeding from the endoskeleton.* In addition, the exoskeleton, under this inferior type, sometimes contributes large epidermic additions in the shape of sheaths to the horns, as well as hoofs to the feet.

III. The *third* group of Herbivores includes only the *Sirenians*—aquatic species that fail of hind-limbs, like Whales, but bear various marks of superiority to the Mutilates, as already briefly indicated.

The grand divisions of the tribe of Herbivores, which have been pointed out and elucidated in the preceding pages, are indicated in the following Synopsis, together with the subdivisions to which we appear to be led by the further application of the principle of cephalization. In connection, one or two of the more prominent distinctions of the higher groups are mentioned.

Synopsis of the proposed classification of Herbivores.

I. Sthenorhines.

Prosthenic. Snout serving as a power-organ, usually elongated. Gross-amplificate, rarely long-amplificate in extinct species. Horns, when any, proceeding from the exoskeleton alone, nasal.

1. PROBOSCIDEANS.—Snout an organ of digital as well as brachial prehension. Imparidigitate.

(1.) Elephantids.
(2.) Dinotherids. (?)

2. TAPIRIDEANS.—Snout imperfectly, or not at all, prehensile, there never being prehension at the extremity (or digital prehension). Imparidigitate.

(1.) Rhinocerotids.—Having a nasal horn.

(2.) Tapiroids.—Without a nasal horn. Snout elongate, often imperfectly prehensile.

a. Tapirids.
b. Paleotherids.

(3.) Hyracids.—Without a nasal horn. Snout not elongated.

3. SUIDEANS.—Snout elongate, but not at all prehensile. Paridigitate.

(1.) Suids.
(2.) Hippopotamids.

II. Sthenomeres.

Metasthenic. Long-amplificate, even when gross-amplificate. Snout not a power-organ. Horns, when any, proceeding from the endoskeleton, frontal.

1. SOLIPEDS.—Without horns. Imparidigitate.

(1.) Equids.
(2.) Macrauchenids. (?)

2. RUMINANTS.—Having horns in the typical group, except often in females. Paridigitate.

(1.) Cornigers.—Having horns. Frontiferient.

a. Cervids.
b. Antilopids.
c. Camelopardalids.

(2.) Nudifronts.—Without horns. Not frontiferient, feeble in self-defense.

a. Camelids.
b. Moschids.
c. Anoplotherids.

3. ————— ?

III. Sirenians.

Urosthenic, natatorial. Having a large caudal fin for swimming. Posterior limbs wanting.

Manatus, Halicore or Dugong, Rytina, etc.

In the following enumeration of the distinctions of the several subdivisions, I confine myself almost entirely to those characteristics which are obviously based on the principle of cephalization, omitting the many anatomical details to be found in zoological treatises.

A. *Subdivisions of the Sthenorhines.*

(1.) The *Proboscideans* are distinguished by the high characteristic of having in the proboscis a prehensile organ of great

power and perfection—one that combines the qualities both of a prehensile hand and a grasping arm, and which, therefore, is more serviceable for prehension than the fore-limb of a Carnivore. Although this is a perverted use of a nose, it is not supposed to be attended with any degeneration of the normal sense below that of other Herbivores. The elliptic condition of the jaws in the species is connected, as already explained (Art. I, p. 400), with the enormous development of the tusks. The forelimb is proportionally as short as in the Lion, and the hand-portion even shorter, its length being only *one-half* that of the humerus.

The Dinothere appears to show in its skull that it was a true Proboscidean, that is, an animal with an Elephant-like proboscis. If so, it was, in all probability, a terrestrial animal, like an Elephant, or not more aquatic than a Hippopotamus. The fact that prehension is a characteristic of Carnivores and the higher Mammals, and, among terrestrial Herbivores, only of the superior species, indicates that it is a mark of high grade, and, therefore, one that is not likely to be associated in such perfection as that of the Elephant with the structure of an aquatic natatorial Herbivore.

(2.) The *Tapirideans* are related to the Proboscideans in the snout, and to the Suideans in this and many other characteristics. Unlike the latter, they are imparidigitate, the third finger being the longest. The cranium is considerably elongated, being from one-half to two-thirds longer than the humerus, and thus diverges widely from the same in the Carnivores.

The family of the Rhinocerotids is distinguished by the greatly thickened nasal bones and the nasal horn, and by the snout not being at all prehensile. The joints of the fore-limb in the *Rhinoceros Javanus* have very nearly the same proportional length as in the higher Carnivores; but the cranium as compared with the length of the humerus is one-third longer.

The Tapiroids have the snout prolonged, and often, if not always, somewhat prehensile, the prehension being brachial in kind and not digital; and the fore-limbs have the outer or *fifth* toe well developed, while the inner or *first* is wanting, thus showing inferiority (according to the principle stated on page 162) both to the Rhinoceros (3-toed) and Elephant (5-toed), in each of which the toes are nearly balanced either side of the *third*. In one division of the Rhinoceros group, including the extinct species made into the genus Acerotherium by Kaup, the toes of the fore-limbs are four in number, as in the Tapir, and besides this the horn is absent; and if, as suggested by Blainville, the so-called Acerotheres are only females, there is no question that this extra outside toe without a first is, among the imparidigitate Herbivores, a mark of inferiority, as argued on page 162. The same conclusion might be drawn, though less safely, from the fact that these

Acerotheres (whether females or not) are among the earliest geological representatives of the Rhinoceros group.

The Hyracids are degradational forms, having the snout not prolonged and not horned, yet having it terminate in a flat naked space with the nostrils on either side, also having the tail reduced to a mere tubercle, and having the small size, as well as some of the habits, of a Rodent of the Hare family. It is good at digging. This abbreviation before and behind in the Hyrax may be an example under the *elliptic* method of decephalization, evincing feebleness in a life-system which is of extreme smallness for the Herbivore-type. The animals of the little Syrian species were long since described as "a feeble folk." (Prov. 30 : 26).

3. The *Suideans* are generally acknowledged to be far more closely related to the Tapiroids than to the other Paridigitates (or Ruminants). Yet they bear many evidences of inferiority to that group. Besides being paridigitate, they have the jaws more amplificate than in the Tapirs, as appears in the fact that the extremity, bearing the incisors and canines, is more remote from the molar portions, and still more strikingly, in many species, in the canines being elongated into tusks, and the incisors also being sometimes large and spaced out. This amplificate condition reaches its extreme in the Hippopotamus. There is also a great tendency to gross-amplification through the development of fat—the lowest kind of amplification. Another hypotypic feature is the graceless and bizarre forms of many species. Still another is the abnormal reverted growth of the upper canines, which, in one species, the Babyroussa, pass out through the facial part of the skull, becoming long curving nasal horns. Still another evidence of inferiority is the very small size of the brain compared with that of the head.

The Hippopotamids are extreme examples among Pachyderms of gross-amplificate structures, and are evidently hypotypic species in this hypotypic group. They manifest this in their size, grossness of head and body, aspect of deformity in every part, soldered radius and ulna, and in their being the most aquatic of the group. Their unusually short legs and spread toes, also, are evidently marks of inferiority; for in a system so low in structure throughout, these peculiarities cannot be a consequence of high cephalization. It is a step toward the Mutilates.

B. *Subdivisions of the Sthenomeres.*

1. The *Solipeds* rank the Ruminants, not only because imparidigitate, but also, because of their higher grade of digestive system, and the bare forehead; for in these species absence of horns appears to be a mark of elevation. That they are the highest of Sthenomeres is also evident from the elegance of form,

grace of motion, fleetness and strength which characterize one or more species of the group, and which combination of qualities is presented in equal perfection in no other Herbivore. The type, therefore, may rightly claim the first place in its grand division, and not a subordinate one, either between Tapirs and Rhinoceroses or Hogs, or below Goats and Oxen.

The Macrauchenia, according to Owen, was much like a Ruminant in its *legs*, although *imparidigitate*, and near the Camel in its *neck*, while it had *probably* (the head is yet unknown) no Tapir-like proboscis. The radius and ulna were united, and so also the tibia and fibula. Its place in the system may be, therefore, along side of the Equids, or the imparidigitate Sthenomeres. If, however, the animal had a proboscis, the species would fall among the Tapirideans and represent an inferior long-amplificate subdivision. The term *Solipeds* or *Solidungulates*, might well be replaced by *Equideans*, as the existence of a *solitary* hoofed toe is not an essential characteristic of the group.

2. The *Ruminants* are naturally divided into two groups.—

(1.) The *Cornigers* or typical species.—These are (*a*) furnished with horns (whence the name applied to them) at least in the males. They are (*b*) *frontiferient*, that is, strike with the forehead in attack. (*c.*) The foot has great compactness, the two principal toes (normally the *third* and *fourth*) being so large, and so well hoofed, that the animal walks upon them; the hoofs are flat on the inner side and fit well together, so as to look and act much like one cloven hoof. (*d.*) The two posterior toes (*second* and *fifth*) are too short to touch the ground, and are sometimes altogether wanting. (*e.*) Two metacarpals, and also two metatarsals, are, with a rare exception, coalesced into a single "cannon-bone"; also, the scaphoid and cuboid bones, at the base of the cannon-bone, are united. These particular characters are here enumerated in order to exhibit the contrast between this type and that of the Nudifronts.

The two families of Cervids and Antilopids, mentioned in the Synopsis, page 169, are the same in limits as those usually so named, except that the Camelopard is excluded. The Camelopardalid is the special long-amplificate, or Heron-like group, under the Corniger type. The horns are persistent, as in the Antilopids; but instead of a corneous sheath, they have for a covering only the hairy skin. In this respect and, further, in their extreme long-amplification, in the young animal's having horns at birth, and in their using the hind-legs in kicking as the principal means of defense, like the Horse, (and not merely as the occasional, like many Ruminants,) they diverge from the other Cornigers and rightly constitute a separate family, and one *hypotypic* in grade. It is stated that the males sometimes make use of their horns in attack; and one female at the Zoological Gardens, London, is said to have driven her horns through an

inch board. As the head of a Camelopard is raised seventeen or eighteen feet above the ground, the systemic force in this inferior Herbivore is diffused through a sphere whose radius is nearly twice that of the Lion, and six to eight times that of its superior among Herbivores, a common Stag or Goat—a condition betokening very low grade. Its inferiority among Cornigers is also apparent in the small head and brains for so large a body, its singularly awkward use of its long limbs when running, and its being a *mute* animal.

(2.) The *Nudifronts*.—The Nudifronts manifest their inferiority to the preceding in different ways.—

(*a.*) In a comparatively relaxed condition of the extremities.

In the *Camelids*, the toes spread forward so that the animal walks on a pad or pads beneath the foot and toes; the hoofs are small, of symmetrical shape instead of being fitted to one another, and cover only the extremities of the toes; the scaphoid and cuboid bones of the tarsus are disjunct; and the cannon-bone, though single, is divided at its lower extremity to a higher point than in the Cornigers.

In the *Moschids*, the toes are lax, as in the Camelids, and similarly covered with short hoofs, so that there is not the appearance of a single cloven hoof; moreover the two posterior toes are elongated so as to touch the ground in walking; and, in one species, not only are the scaphoid and cuboid bones disjunct, but also the metacarpals and metatarsals which make up the cannon-bone of the Cornigers and Solipeds. In others, also, the metacarpals are not completely coalesced.

The *Anoplotherids* are like the Moschids in the lax condition of the two large toes; and, as in the *Moschus aquaticus*, the scaphoid and cuboid bones are disjunct and also the metacarpals and the metatarsals.

(*b.*) In the forehead not being a power-organ, and not furnished with horns.—

This condition in an animal may be a mark either of a highly cephalized, or of an enfeebled, life-system. In the Horse it appears to be the former. But in the Nudifronts, it is so associated with other proofs of inferiority that it is unquestionably additional evidence of this inferiority. Absence of horns characterizes the *females* of many Cornigers, which shows that it might naturally be a feature of related inferior species.

The Camel and Musk-deer have feeble heads, both as respects mechanical and psychical power. The Musk-deer not only has no trace of horns but the forehead is not used in defense or attack, being apparently unfitted for this purpose.

(*c.*) In their feeble means of defence and bizarre shapes.—

The Camel sometimes bites—an almost universal propensity among animals, there being a consciousness of power in the

jaws when none elsewhere. The male Musk-deer is aided by long canines; yet it is a very timid animal, and although it takes extraordinary bounds when fleeing from a pursuer, it is said to become very soon exhausted, and thus is a little after the Grasshopper-style among hypotypic Insects. The Llamas spit.

The Camel has a body out of proportion to its legs, and exhibits awkwardness in features and gait; its hump is an abnormal growth of fatty and cellular tissue, having no functional value beyond that of serving as fuel for the craft when out on the desert; and its formation evinces large vegetative powers with consequently feeble systemic control.

(*d.*) In the presence of canines in most of the species; and in the Anoplotherids the set of teeth, besides being complete, having the canines short and not projecting, as in Man.—

The variation from the Ruminant type in the teeth shows a tendency to return to normal regularity and simplicity, as is common in *inferior* species (Art. I, pp. 326, 440), and is not a mark of elevation toward the Pachyderms.

Owen observes that an Anoplotherid resembles, in its absence of horns, its divided metatarsals and metacarpals, its lax toes, and its even and normal number of teeth, "the embryo Ruminant," these characteristics of the embryo being retained in them through adult life. He speaks of it, again, as exhibiting the features of the more generalized (or less specialized) Mammalian type, and remarks upon the same as also shown, though less strikingly, in the Camel. This relation, so correctly presented, accords with the view we hold, that these species are low in grade of cephalization; for a condition analogous to that of an animal in an unfinished or young state is one of comparative feebleness. The embryological resemblance, on this view, extends not only to *form* but also to *force*.

The *Pachydermatoid* qualities in the Moschids, and some among those so regarded in the Camelids, correspond therefore to a *degradation* of the Ruminant-type.

On page 165, the long-amplificate jaws and limbs of Solipeds and typical Ruminants are shown to be mutually dependent on that condition of the systemic force which is essential in order to bring out the Ruminant type-structure. It here appears that the *relaxed* or enfeebled condition of that force which leads to a lax state of the digits or extremities of the limbs is attended by modifications of the teeth—the dental series losing its type-character by the development of some or all of the missing teeth, and so returning toward elemental regularity. The two extremes of the body, the jaws and the limbs, thus vary together with the enfeebling or relaxation of the systemic force.

It is apparent, from this survey, that the Nudifronts are distinct from the higher Sthenomeres in several important characteristics,

indicative, each, of inferiority of grade. They are feeble in the head, and have no use for the forehead in attack or defense; they are weak as to means of defense of any kind; they have a lax condition of the extremities; they have a more complete and regular series of teeth, but as a result of a more diffused state of the systemic force, or less systemic control.

C. *Sirenians.*

The distinctions of the Sirenians have already been sufficiently indicated (p. 169).

In conclusion, the writer may here state that he does not look upon the classification which has been presented, as in all points that to which *beyond question* the right application of the principle of cephalization leads; but only as that which, as far as he now understands the facts and the principle, appears to him to be correct to nature.

D. *Dynamical considerations.*

1. *Amplification.*—On page 165 it is shown that in the skeleton of the long-amplificate Herbivores, the head and limbs are both elongated, although unequally; and that the elongation is little or none in the basal portion of these parts, while large in the rest, and especially toward the extremities of both the jaws and limbs.

On page 174, it is likewise shown that a relaxation of the parts in the extremities of the limbs is concurrent with a relaxing also of the elements of the jaws.

Thus the head and the limbs, parts alike circumferential, undergo analogous changes under similar conditions—the amplification in the *head* increasing from the basal portion of the skull toward the extremity of the jaws; and that in the *limbs* increasing from the body toward the extremities of these limbs.

Now it is to be noted that, while the head and the limbs diminish in amplification toward their basal portions, they are separated in the same species by a *long-amplificate neck.* It seems to follow, therefore, that the head is one centre of amplification, and the body another; or, in other words, that there are two distinct centres of amplification, a *cephalic* and a *thoracic*, the former the *primary.*

The question may be asked, whether the neck, in its amplification, should be considered as subordinate to the cephalic, or to the thoracic, centre, or to both equally. In reply, it is to be observed that the amplification in the case of the neck accords in amount much more nearly with that in the limbs than with that in the head. Moreover, short limbs and a short neck go together (as in the natatorial Herbivores and Mutilates), even

when the head is excessively elongated; and when the limbs are reduced to fins, as in Fishes, the neck is essentially wanting. Again, the longer cervical vertebræ are those most remote from the body, and the stoutest those nearest it; and, in the Camelopard, an animal in which the part of the limbs remote from the body is very much elongated, these cervical vertebræ remote from the body are likewise much elongated. It would hence appear that the amplification in the neck in these species is subordinate mainly to the thoracic or secondary centre.

But although this argument in favor of a connection at times between amplification in the neck and limbs may appear direct, we deem it only a doubtful suggestion. In any case, the fact of two systemic centres in Mammals seems to be established—one, the *cephalic* or *superior*, quite small in radius and with narrow limits of amplification; the other, the *thoracic* or *inferior*, very large in radius, and admitting of a wide range of amplification.

In Crustaceans the head and thorax make one single division of the body, the cephalothorax; and the cephalic nervous mass is often quite near the first thoracic, the two in some inferior species being on opposite sides of the esophagus. The cephalothorax here corresponds, therefore, to one single primary centre; and this centre is situated near the anterior margin of the mouth-aperture, or between the mandibular and 2nd-antennary segments, where it is placed by the writer in his former articles on this subject. There is an inferior or *secondary* centre in Crustaceans, but this is abdominal, as remarked in Art. I, p. 322. In Insects, as the body consists of three parts, a head, thorax and abdomen, there appear to be, besides the cephalic, two secondary centres, a thoracic and an abdominal; and in the Mantids and like species we have an example of a large anterior amplification of the thoracic. At page 328 of Art. I, a fact is mentioned bearing on the existence of two centres in Worms.

While amplification, then, depends on the degree of systemic control over vegetative growth and development, it may take place about the structure as a systemic unit, or about its primary and secondary systemic centres; and each centre may be more or less independent of the others in the amplification subordinate to it.

When, in an organism, the systemic force controls in the highest possible degree, under the type, the tendency to vegetative increase, or the mere powers of growth (the centrifugal tendency), there is the highest concentration and greatest circumferential contraction; and when in any less degree, there is amplification or circumferential extension.

When the systemic control is still so great as to keep the parts essentially within typical proportions as to relative lengths of parts, the amplification, if any, is simply gross-amplification—gross-amplification of the whole bony structure in superior spe-

cies, and of fatty, cellular and dermal tissues mainly, in species of a feebler life-system. But when the control is less complete, the parts of the bony structure increase *in length* by amplification, especially the more circumferential portions of them—*this amplificating tendency increasing in amount with the distance from the systemic centre or centres*—and the structure is long-amplificate. With a feebler life-system, not able to keep the structure evolved to type-perfection, the limbs may have lax or imperfect extremities, that is, lax as compared with their condition in the typical species under the type.*

2. *Definiteness of the distinction of gross-amplificate and long-amplificate.*—It has been observed that the two higher groups of terrestrial Herbivores are distinguished, the first, by being very generally gross-amplificate in the structures included, and the second by being long-amplificate, and that the two groups are thus quite well separated, there being but few cases of long-amplification in the former, and the gross-amplification in the latter taking place upon long-amplificate structures. It is a general fact throughout the animal kingdom that the long-amplificate groups under a type stand apart from, instead of blending insensibly in this respect with, the typical or gross-amplificate groups. Thus there is a Tipulid group among Dipters; a Grallatorial group among Birds of the tribe of Præcoces; a Heron group among the Altrices; a Serpentarius family among the Accipiters, etc.

The reason for this definiteness of limit between gross-amplificate or typical forms and long-amplificate is apparent from the preceding discussion. To produce the former, there is the systemic control which determines typical proportions and admits only of narrow limits of variation. For the latter, there is a diminished degree of that control, leaving vegetative growth to elongate the structure; and this diminution is not one of gradual stages, but an abrupt step down to the new condition. The limits of typical proportions once fairly overstepped, the structures pass suddenly to amplificate forms of very varied proportions. This capability of elongating the bony skeleton in Sthenomeres is very different from that of mere general enlargement which characterizes the Sthenorhines; and without an abruptness of transition between the two conditions the two types would not stand as far apart as they do in style of amplification.

3. *Axial distribution of force.—The retroferent method of decephalization.*—There is another law with regard to the systemic force, to which the above, relating to amplification, is actually subordi-

* The separateness of these two powers is also illustrated by the arrest of development in the brain, in many cases, as shown by fewer gyri and a greater simplicity of folds, while there is an increase of size up to normal dimensions. See W. C. Minor's translation of articles by Dr. Wagner, in this Journal [2], xxxiv, 188, and, in particular, the remark of Dr. Minor on this pofnt, on p. 199.

nate—which is, that *the force may vary in cephalic concentration, and thereby in its distribution along the principal body-axis.*

It has been shown in this and the former articles that there is often, with descending grade of species, a transfer of force and function backward in the structure—a method of decephalization termed the *retroferent*, and including under it, the *prosthenic*, *metasthenic* and *urosthenic* conditions of structure. These have been illustrated from all departments of the animal kingdom; and with examples from Herbivores in the preceding pages. We refer again to the facts among Crustaceans in this Journal (vol. xxii, 14, 1856, and the chapter in the author's Expl. Exped. Report, p. 1412,) as especially clear and conclusive, and as having peculiar interest because historically the source in the writer's mind of the principles here explained.

Moreover, this backward transfer of force and function manifests itself also in the posterior elongation of the structure and also in some anterior dilation. Conversely, elevation of grade is manifested in the abbreviation of the structure behind, and to some extent also anteriorly, and in the transfer of force and function forward, or toward the cephalic extremity.

This connection of grade with a transfer of force along the body-axis—through a weakening or strengthening of the cephalic concentration—is dependent on the polar or cephalic nature of an animal—a condition remarked upon in Art I, at page 321, and referred to at p. 157 of this paper. The higher the grade of a species under a type, the greater the extent to which the force of the system is gathered in, or toward, the cephalic extremity or pole; and the lower the grade, the more complete its diffusion toward the posterior extremity.[9]

In the forward transfer attending cephalic concentration, the anterior limbs, as the species rise in prosthenic character, increase in muscular force, so that, as in Carnivores, this force is far greater in the fore-limbs than in the hind-limbs. When the transfer of force toward and about the anterior or cephalic extremity is at its maximum under any type, the structure is *prosthenic* in the highest degree possible for that type. But if the anterior extremity of the body-axis is not in this maximum state, owing to a diffusion of the force posteriorly, the condition is one less prosthenic; by a further loss and diffusion posteriorly, there may be another step down (for such transitions, as we have before found, appear to be by a *saltus*) perhaps to a lower grade of prosthenic, or else, still lower, to a *metasthenic* condition, and attending this, there is often an increasing length of body; by a further loss or diffusion posteriorly, there may be the pro-

[9] In my last article (Art. II, p. 10) I have referred the amplificate and retroferent methods of decephalization alike to *apocentric* distribution of force—or diffusion away from the principal or cephalic systemic centre. This, although true, is but an imperfect expression of the fact.

founder descent to a *urosthenic* condition, with great length behind and a large part of the force of the structure thrown into the caudal extremity.

But, besides the increase of muscular force attending cephalic concentration, there is also increase of cephalic force—the sensorial and higher cephalic—an increase which is not so easily measured or compared. Man is probably prosthenic looking only to his limbs, the arms being stronger than the legs. Yet this is but a small fraction of the force which makes him the prosthenic being he is. The force is so largely purely cephalic, that he may be styled, with special appropriateness, *cephalosthenic*. In such a species the increase of force along the body-axis from behind forward would be represented by a very rapid divergence of lines; in a Carnivore, by a divergence much less rapid; in a Whale by lines diverging but little from parallelism.

When the supremacy of the cephalic extremity in an organism is of high order, the cephalic centre is near the front margin of the head. Thus in Man, the being eminently of onward head-power, the jaws project but slightly beyond the anterior margin of the brain; moreover this cephalic concentration and contraction is connected with a reduction of the number of teeth from 44 to 32, one pair of incisors and two of premolars being wanting in either jaw out of the full number that belongs to the Mammal type. There is a great contrast between this abbreviated form of head and the elongated cranium of the 44-toothed Anoplothere, one of the lowest of Herbivores.

When the cephalic supremacy is so feeble that the force approximates to equality along all parts of the body-axis, the animal is the next thing in grade of life to a plant; the cephalic centre in such a case often has a position remote from the anterior extremity, the head portion becoming greatly dilated, as in the Whale as mentioned on page 160. If, in addition, the systemic force is feeble, the body may be contracted both before and behind, about the *nearly central* cephalic pole, as in Radiates.

With decreasing cephalic concentration, there may be not only increasing length throughout the structure, and especially circumferentially, but also an increasing relaxation of the parts of the structure, and a tendency toward a resolution into its normal elements, or an elementalizing of it; and also a tendency toward an equality in the series of parts or elements. This is decephalization by the *analytic* method explained in Art. I, p. 326.

The same kind of relaxation, favors not only ordinary vegetative increase, and an analytic resolution of structure, but often, also, that extraordinary multiplication of parts included under the *multiplicative* method of decephalization (Art. I, p. 325), and that multiplication of ova or young at a birth, included under the *genetic* method (Art. I, p. 330). In the higher animal species,

the forces and material of the being can develop at one time but one or a few ova; in others inferior, the amount required for each is so small, or, is so small a part of the whole energies of the individual, that the number produced is almost indefinitely large.

4. *Relation of the law of amplification to the law of axial distribution of force.*—The condition as to the distribution of force along the body-axis under a type, determines, as has been shown, the form or general nature of the structure, in any case, and the structure thus established is that which undergoes amplification. Thus the law of amplification is secondary to the law of axial distribution. Gross-amplification in a Whale is amplification of a *urosthenic* structure, or one in which the forces are so distributed along the axis that the anterior pole is not very highly superior to the posterior—a structure which is of great length and size behind *because* urosthenic, or feeble in cephalic polarity, while, at the same time, powerful in life-system.

5. *Diminution of cephalic concentration or polarity not necessarily a diminution of the total amount of force in an organism.*—As a Whale has more locomotive force than any other animal, it is evident that the transfer of force posteriorly, or the loss of cephalic concentration, does not necessarily involve a great diminution of strength of body: in a transfer of force, there is not necessarily a lessening of force. In fact, it might be inferred from the case of the Whale, and also from examples among the higher Mammals, that sensorial and other higher cephalic force becomes converted, in the transfer posteriorly, into muscular force; so that a Whale is a representative of the force of a typical megasthene,—a Lion, for example—in the condition almost exclusively of *muscular* force. The last part of this statement may be quite true; for the Whale may not differ from a Lion so much in amount of systemic force as in the proportions of that force divided between the several kinds of muscular, sensorial, and psychical. But this commutation of kinds of force cannot properly be admitted. It is more correct to say that the systemic developments in one case produce almost solely muscular force; in the other, less of this with a larger proportion of sensorial, or sensorial and psychical; and that these proportions are determined by the cephalic polarity of the life-energy characterizing the organism under development. The brain is the last part of an animal that is perfected. It becomes complete in its powers only after the rest of the structure has so far reached its limits of growth that the whole system may combine its nutrient energies and material on the one great feature of the being. In this way the cephalized structure attains its most highly cephalized condition.

The views here set forth rest on the ground that in a living organism there are not only molecular forces everywhere individually at work, carrying on all changes and growth, but also

that there is centralized control over all molecular forces, determining the limits, nature and condition of the organism.[10]

I would not be understood as including Man's higher nature among the attributes that can be developed out of simple matter and cephalized life. For Man evinces in his power to comprehend Nature's laws and use them for his physical, intellectual and moral progress, that he is *above* Nature. He shows in his thoughts of the infinite—in his recognition of an omnipotent Creator, (or, as well, in his efforts to reason himself out of this recognition, or into the substitution of an infinite Nature)—in his sense of obligation to moral law, and law as emanating from an infinite God—in his aspirations towards the infinite—in his hopes reaching into the indefinite future—and in his capability of indefinite development, that he has within him an element of the infinite, a spiritual element, which places him above nature, constitutes his likeness to his Creator, and assures him of a future of spiritual existence apart from matter and its inferior developments.

6. *Distinction of Megasthenes and Microsthenes.*—The fact stated with regard to the powerful life-system of the Whale affords aid towards a definite understanding of the distinction between the great groups of Megasthenes and Microsthenes. The subdivisions of these groups are mentioned in a note to page 159, and in a manner to exhibit their parallelism:—the Quadrumanes and Chiropters being in one line, since they have long been regarded as correlates in many of their characters; so Carnivores and Insectivores in the second; Herbivores and Rodents in the third; and Mutilates and Edentates in the fourth. Carnivores and Insectivores are both carnivorous and both prosthenic tribes. Herbivores and Rodents are both herbivorous, and the larger and most characteristic part of the former and all of the latter are metasthenic. Mutilates and Edentates are both degradational types; the latter, like the former, sometimes multiplicate and elementalized in their teeth, sometimes wholly elliptical as to teeth, sometimes vast in amplification; and bearing, through all their structure, evidence of great inferiority among the placental Mammals. The mean sizes of the Megasthenes and Microsthenes have been shown to be about as 1 : 4.

Now the Whales, by their enormous muscular power, make it manifest, as has been explained, that they are true Megasthenes, or that the life-system is really large, not very much smaller perhaps than that of the higher Herbivores. Although degradational species, they still retain this peculiar feature of the Megasthenic type.

[10] This idea is illustrated by reference to the nature of coral polyps in the writer's Report on Zoophytes, 4to, 1846.

The Edentates are also large beasts, and the first impulse, under the influence of the sense of sight, is to declare them likewise Megasthenes, because they are big enough to be so. But these animals, large and small, while degradational like the Mutilates, are in striking contrast with the latter as regards muscular force and all other powers. They are cephalically feeble, below other Mammals; and they are of extreme muscular debility as compared with a Whale or any Megasthene. There is no increase of muscular power *because* of the degradation of the sensorial and psychical elements, as in the Whale, but a general degradation of every function and part. Thus they are literally microsthenic in life-system. Compared even with a quick-moving Rodent, the slow Sloth is muscularly feeble; for relative strength is to be measured, not by the single blow that may be given, but by the product of the strength of a single blow into the number of times this blow may be repeated in a given time, as for instance, in twenty-four hours.

The Edentates appear therefore to be as truly degradational *Microsthenes*, as the Mutilates are degradational Megasthenes. They show their feebleness according to the elliptic method, in their head and jaws to an extent not manifested even among Mutilates.

The Edentate type exhibits its inferiority to that of all other placental Mammals also in admitting more or less of a commingling of Reptilian characteristics with the Mammalian, as appears in the scale-made or shield-like armor of many species, the feeble sensibility of all, and several peculiarities in the skeleton: —showing thus that the type holds a position in some respects between those of Mammals and Reptiles, or at the extreme lower end of the placental series.

D. *Additional Observations.*

1. *Grade among groups.*—The groups under the several subdivisions in the proposed classification show a gradation in rank corresponding with their position. Moreover, the third group, as in the higher subdivisions of the animal kingdom, and in those presented in the article on Insects, is literally a *hypotypic* group. The hypotypic features are connected either with a more or less aquatic mode of life, and gross-amplification, or with long-amplification.

It may be here observed that were we to make the Imparidigitates and Paridigitates the two grander divisions of Herbivores, and so unite the Solipeds to the Proboscideans and Tapirideans, and the Suideans to the Ruminants, the Solipeds would have to go, because *metasthenic*, at the foot of the higher division, when they have the characteristics of a *superior* typical group, and not those of a hypotypic; and the Suideans would

take their place at the head of the lower, before the Ruminants, because *prosthenic*, although decidedly hypotypic in shape, structure and stupidity.

2. *Designations of the grades of subdivisions in the tribe of Herbivores.*—Under the tribe of Herbivores, the subdivisions of the first grade, that is, those of Sthenorhines, Sthenomeres, and Sirenians, may be conveniently named *subtribes*. The subdivisions of the second grade, or those of Proboscideans, Tapirideans, etc., may be called *tribules*, this word being diminutive of *tribe*.

The subdivisions of the third grade are, with three exceptions, *families*. The three exceptions are that of the Tapiroids among Sthenorhines, and those of Cornigers and Nudifronts among Sthenomeres, for each of which the term *stirps*, one already somewhat in use in classification, might be employed. The name of the group of *Rhinocerotids* might be written Rhinocerotoids, so as to make it coördinate with that of Tapiroids; but it would still contain only the single family of *Rhinocerotids*, and the change would be adding words to the system without sufficient reason.

3. *Geological History.*—The earliest of Herbivores in geological history, or those of the opening Tertiary period, were mostly species of Tapiroids and Nudifronts—*Lophiodon* (Tapirid) of the earliest Eocene, being one of the genera of the former, and *Dichobune* (Anoplotherid) of the same epoch, of the latter. The Lophiodonts led off, therefore, the Sthenorhines, and the Dichobunes, the Sthenomeres. Later in the Eocene, if not cotemporaneously, there existed the Paleotheres and the true Anoplotheres, as other representatives, respectively, of these two grand divisions; and with these there were species of Suideans of the Chœropotamid type. The Sirenians were also among the first of Herbivores; and the earliest Eocene genus of these *urosthenic* species, Halitherium, was related to the Halicorids.

It is to these Eocene species, according to all analogy, that we should look for the closest approximation of the two grand divisions of terrestrial Herbivores. And so in actual fact, the Anoplotherids, as long since observed by Cuvier, have near relations in structure to the Tapirids and Suids among the Sthenorhines, as well as to the Camelids among Sthenomeres. This accords in general relation with the facts among Insects mentioned at page 33 in Art. II.

In the Paleotheres, among the earliest of Sthenorhines, moreover, there was, besides an approximation to the Sthenomeres in general structure, an approximation also in long-amplification (p. 168), a feature which is typical for the Sthenomeres, but which disappeared almost entirely from among the Sthenorhines in the later exhibitions of the type.

ART. XIV.—*Note on the position of Amphibians among the classes of Vertebrates;* by JAMES D. DANA.

IN a recent article by the writer on the *Parallel relations of the classes of Vertebrates*,[1] Amphibians are made the inferior division of the class of Reptiles. The usual arguments against this view were not alluded to because they were believed to be familiar to all interested in the subject, and their discussion at the time seemed not to be required. A few words with regard to them are here added in order to set forth more distinctly the special value of the analogies appealed to in that paper.

The evidence in favor of separating the Amphibians from Reptiles as an independent *class* is undeniably of great weight. Their approximation to Fishes in embryological development and the corresponding divergence from ordinary Reptiles have the appearance of being decisive proof that they are as closely related to Fishes as to Reptiles, and, therefore, that they occupy an intermediate position between the two in classification.

The chemical researches on the composition of eggs by Fremy, made a few years since,[2] claiming to show among their results "the curious physiological fact that Amphibians, besides passing through an early condition of existence like that of Fishes, lay eggs which have the greatest affinity in chemical composition to those of Fishes," seemed to the writer, when they were first published, to carry the evidence to the most fundamental point in the nature of the species, even below that of embryological development. If the fundamental elements thus differ, should not the superstructures also, and far more widely?

But the question recurred whether in the subdivision of the subkingdoms of animal life into classes, it is not, after all, the more correct method to take note primarily of species in their finished or adult state; that is, whether adults do not express the true idea and nature of species, or the objects to be classified, rather than the special series of changes through which the adult characteristics are reached.

In favor of an affirmative reply to this question, the fact stands out prominently that, as regards the subkingdoms in animal life, embryology in the hands of the best embryologists has only sustained what Cuvier had derived from the study of the adult animals themselves; and in the hands of other embryological investigators, and some of the latest, even these great natural groups have not been left without mutilation. And as to the subordinate divisions under the subkingdoms there is not only great diversity in the different embryological systems, but violations of natural affinities in all. Professor Agassiz, in his Essay

[1] This Journal, [2], xxxvi, 315, November, 1863.
[2] This Journal, [2], xix, 38, 238, xx, 65, 1855, from the *Journ. de Pharmacie*, 1854.

on Classification,[1] criticizes the systems of Van Beneden, Kölliker and Vogt, on account of their violating the structural affinities of groups, implying that embryological conclusions have to be tested by a reference to the natural types of structure. In nature a specific type is often expressed in a long series of species running through a very wide range of grade; and structures so diverse in grade as those of the higher and lower extreme groups are diverse in the nature of the changes which take place in the course of embryological development. Not appreciating this fact, embryological systemists have cut the series, and made bold demarcations between parts that are essentially one in type. Thus has resulted the separation of the class of Worms from Articulates by both Van Beneden and Vogt, and of the order of Cephalopods from Mollusks by the latter, etc.; and such errors will continue to attend upon the decisions of pure embryology until the precise value of its characteristics in classification is understood.

If, then, the structural relations of the developed animals are an authority to which embryology must appeal, the adult Amphibians may claim to be considered, on a question of their relations to ordinary Reptiles, even before their eggs and young. Embryology proves that Amphibians and ordinary Reptiles are *distinct groups*, as is proved also by structural considerations; but, in the present state of the science, it can hardly be said to demonstrate that these groups are *classes*, coördinate with those of Birds and Mammals;—and I venture to say, as regards the separation of groups, that, in no state, will it prove what the adult structures will not sustain.

But, further, if it were proposed to make a Reptilian whose early life should be aquatic, could it be accomplished by means of eggs having the same chemical constitution as those of ordinary or terrestrial Reptiles? The development, at each step, involves, and depends upon, chemical changes; and it is hence

[1] See the first volume of his Contributions to the Natural History of the United States (pages 220 to 232). Even von Baer, as here quoted, in subdividing the placental Mammals, places in one group the *Carnivores*, *Insectivores* and *Rodents*, and in another *Man*, *Monkeys*, *Ruminants*, *Pachyderms* and *Cetaceans*. Van Beneden divides the Invertebrates into two groups, the *first*, including Insects, Myriapods, Spiders and Crustaceans, the *second*, the subkingdom of Mollusks, *the inferior part of the subkingdom of Articulates*, that is, *Worms*, together with the Radiates, Rhizopods and Infusoria; and his division of Polyps, among the Radiates, in his latest amendments of his system, *includes both Polyps and Acalephs*. Vogt makes three grand groups of animals: the *first*, including Vertebrates, and all Articulates *excepting Worms;* the *second*, Mollusks, Worms and Radiates; the *third*, Infusoria, and Rhizopods; and his division of Mollusks *does not embrace the Cephalopods*, while it does include a tribe of Acalephs. Recently, Prof. Huxley, in lectures before the Royal College of Surgeons, of which a report is given in the Medical Times and Gazette, for May, 1863, says, (page 555,) after discussing the importance of the placenta in Mammals as a basis of classification, that, in his view, there is no difficulty in the way of a classification which unites the Proboscideans with the Rodents rather than with Paridigitate and Imparidigitate Herbivores.

reasonable to infer that the egg which was to be developed when bathed in *water* should thus differ somewhat from one that was to be developed in the *air;* and also that such *aquatic* eggs should approach in constitution those of the true *aquatic* Vertebrates, or Fishes. We may safely conclude, further, that the method of development for eggs thus different in constitution, and at the same time of inferior grade, would necessarily differ from those of ordinary Reptiles, and differ by approximating to those of Fishes. Accordingly, in Amphibians there may be only that divergence from the method of making a Reptile that was required in order that a division of inferior Reptiles should exist characterized by a fish-like life in the young state.

The fact is that the *superstructures* (p. 184) do *not* widely differ. In the adult state the species are Reptiles in all essential structural characters:—they are air-breathing; they have imperfect circulation and, consequently, are cold-blooded; and outside or inside there are no fundamental differences in type that would require a separation from the Reptilian class. The divergence is small compared with that between typical Amphibians and Fishes.

Such considerations are sufficient to authorize the assertion that the evidence in favor of regarding Amphibians as Reptiles at least balances that on the other side, if it does not outweigh it.

Now add to the above the analogy drawn from other classes of Vertebrates, as presented in the paper referred to in the opening paragraph of this article:—that the class of Mammals has its *inferior* subdivision—the Oötocoids, or *semioviparous* species—intermediate between ordinary Mammals and the *oviparous* classes below; that the class of Birds, according to recent discoveries, has its *inferior* subdivision—the Erpetoids, or *Reptilian* species—between ordinary Birds and *Reptiles;* and that between ordinary Reptiles and the class below, or that of *Fishes*, there are the Amphibians, or *fish-like* Reptiles; also, that the grand distinction between semioviparous and ordinary Mammals is manifested in *their embryological development*, or their young state, as well as that between Amphibians and ordinary Reptiles; and the evidence becomes strong that if Oötocoids constitute a hypotypic subdivision of Mammals, so Amphibians constitute a hypotypic subdivision of Reptiles. It is not necessary to repeat at length the argument on this point, as the reader can easily refer to the former paper on the subject. This point is illustrated also in the following article in the same volume (Article I, On the Classification of animals based on the principle of Cephalization) by a wider range of analogies, showing that similar hypotypic groups constitute the lower subdivision in several departments of the animal kingdom.

ART. XV.—*On Celestial Dynamics;*[1] by DR. J. R. MAYER.

THE movements of celestial bodies in an absolute vacuum would be as uniform as those of a mathematical pendulum, whereas a resisting medium pervading all space would cause the planets to move in shorter and shorter orbits, and at last to fall into the sun.

Assuming such a resisting medium, these wandering celestial bodies must have on the periphery of the solar system their cradle, and in its centre their grave; and however long the duration, and however great the number of their revolutions may be, as many masses will on the average in a certain time arrive at the sun as formerly in a like period of time came within his sphere of attraction.

All these bodies plunge with a violent impetus into their common grave. Since no cause exists without an effect, each of these cosmical masses will, like a weight falling to the earth, produce by its percussion an amount of heat proportional to its *vis viva*.

From the idea of a sun whose attraction acts throughout space, of ponderable bodies scattered throughout the universe, and of a resisting ether, another idea necessarily follows—that, namely, of a continual and inexhaustible generation of heat on the central body of this cosmical system.

Whether such a conception be realized in our solar system—whether in other words the wonderful and permanent evolution of light and heat be caused by the uninterrupted fall of cosmical matter into the sun—will now be more closely examined.

The existence of matter in a primordial condition (*Urmaterie*), moving about in the universe, and assumed to follow the attraction of the nearest stellar system, will scarcely be denied by astronomers and physicists; for the richness of surrounding nature, as well as the aspect of the starry heavens prevents the belief that the wide space which separates our solar system from the regions governed by the other fixed stars is a vacant solitude destitute of matter. We shall leave, however, all suppositions concerning subjects so distant from us both in time and space, and confine our attention exclusively to what may be learned from the observation of the existing state of things.

Besides the fourteen known planets with their eighteen satellites, a great many other cosmical masses move within the space of the planetary system of which the comets deserve to be mentioned first.

Kepler's celebrated statement that "there are more comets in

[1] Continued from vol. xxxvi, p. 266.

the heavens than fish in the ocean," is founded on the fact that, of all the comets belonging to our solar system, comparatively few can be seen by the inhabitants of the earth, and therefore the not inconsiderable number of actually observed comets obliges us, according to the rules of the calculus of probabilities, to assume the existence of a great many more beyond the sphere of our vision.

Besides planets, satellites, and comets, another class of celestial bodies exists within our solar system. These are masses which, on account of their smallness, may be considered as cosmical atoms, and which Arago has appropriately called asteroids. They, like the planets and the comets, are governed by gravity, and move in elliptical orbits round the sun. When accident brings them into the immediate neighborhood of the earth, they produce the phenomena of shooting stars and fireballs.

It has been shown, by repeated observation, that on a bright night twenty minutes seldom elapse without a shooting-star being visible to an observer in any situation. At certain times these meteors are observed in astonishingly great numbers; during the meteoric shower at Boston, which lasted nine hours, when they were said to fall, "crowded together like snow-flakes," they were estimated as at least 240,000. On the whole, the number of asteroids which come near the earth in the space of a year must be computed to be many thousands of millions.[3] This, without doubt, is only a small fraction of the number of asteroids that move round the sun, which number, according to the rules of the calculus of probabilities, approaches infinity.

As has been already stated, on the existence of a resisting ether it depends whether the celestial bodies, the planets, the comets, and the asteroids move at constant mean distances around the sun, or whether they are constantly approaching that central body.

Scientific men do not doubt the existence of such an ether. Littrow, amongst others, expresses himself on this point as follows:—"The assumption that the planets and comets move in an absolute vacuum can in no way be admitted. Even if the space between celestial bodies contained no other matter than that necessary for the existence of light (whether light be considered as emission of matter or the undulations of a universal ether), this alone is sufficient to alter the motion of the planets in the course of time and the arrangement of the whole system itself; the fall of all the planets and the comets into the sun and the destruction of the present state of the solar system must be the final result of this action."

[3] Compare Prof. Newton's computation of the approximate number of meteors in the August ring alone, which makes it more than 300,000,000,000,000: this Journal, xxxii, 451.—Eds.

A direct proof of the existence of such a resisting medium has been furnished by the academician Encke. He found that the comet named after him, which revolves round the sun in the short space of 1207 days, shows a regular acceleration of its motion, in consequence of which the time of each revolution is shortened by about six hours.

From the great density and magnitude of the planets, the shortening of the diameters of their orbits proceeds, as might be expected, very slowly, and is up to the present time inappreciable. The smaller the cosmical masses are, on the contrary, other circumstances remaining the same, the faster they move towards the sun: it may therefore happen that in a space of time wherein the mean distance of the earth from the sun would diminish one metre, a small asteroid would travel more than one thousand miles towards the central body.

As cosmical masses stream from all sides in immense numbers towards the sun, it follows that they must become more and more crowded together as they approach thereto. The conjecture at once suggests itself that the zodiacal light, the nebulous light of vast dimensions which surrounds the sun, owes its origin to such closely packed asteroids. However it may be, this much is certain, this phenomenon is caused by matter which moves according to the same laws as the planets round the sun, and it consequently follows that the whole mass which originates the zodiacal light is continually approaching the sun and falling into it.

This light does not surround the sun uniformly on all sides; that is to say, it has not the form of a sphere, but that of a thin convex lens, the greater diameter of which is in the plane of the solar equator, and accordingly it has to an observer on our globe a pyramidal form. Such lenticular distribution of the masses in the universe is repeated in a remarkable manner in the disposition of the planets and the fixed stars.

From the great number of cometary masses and asteroids and the zodiacal light on the one hand, and the existence of a resisting ether on the other, it necessarily follows that ponderable matter must continually be arriving on the solar surface. The effect produced by these masses evidently depends on their final velocity; and, in order to determine the latter, we shall discuss some of the elements of the theory of gravitation.

The final velocity of a weight attracted by, and moving toward, a celestial body will become greater as the height through which the weight falls increases. This velocity, however, if it be only produced by the fall, cannot exceed a certain magnitude; it has a maximum, the value of which depends on the volume and mass of the attracting celestial body.

Let r be the radius of a spherical and solid celestial body, and g the velocity at the end of the first second of a weight falling on the surface of this body; then the greatest velocity which this weight can obtain by its fall toward the celestial body, or the velocity with which it will arrive at its surface after a fall from an infinite height, is $\sqrt{2gr}$ in one second. This number, wherein g and r are expressed in metres, we shall call G.

For our globe the value of g is 9·8164 . . . . and that of r 6,369,800; and consequently on our earth

$$G=\sqrt{(2\times 9{\cdot}8164\times 6{,}369{,}800)}=11{,}183.$$

The solar radius is 112·05 times that of the earth and the velocity produced by gravity on the sun's surface is 28·36 times greater than the same velocity on the surface of our globe; the greatest velocity therefore which a body could obtain in consequence of the solar attraction, or

$$G=\sqrt{(28{\cdot}36\times 112{\cdot}05)}\times 11{,}183=630{,}400;$$

that is, this maximum velocity is equal to 630,400 metres, or 85 geographical miles in one second.

By the help of this constant number, which may be called the *characteristic* of the solar system, the velocity of a body in central motion may easily be determined at any point of its orbit. Let a be the mean distance of the planetary body from the centre of gravity of the sun, or the greater semidiameter of its orbit (the radius of the sun being taken as unity); and let h be the distance of the same body at any point of its orbit from the centre of gravity of the sun; then the velocity, expressed in metres, of the planet at the distance h is

$$G\times\sqrt{\frac{2a-h}{2a\times h}}.$$

At the moment the planet comes in contact with the solar surface, h is equal to 1, and its velocity is therefore

$$G\times\sqrt{\frac{2a-1}{2a}}.$$

It follows from this formula that the smaller $2a$ (or the major axis of the orbit of a planetary body) becomes, the less will be its velocity when it reaches the sun. This velocity, like the major axis, has a minimum; for so long as the planet moves outside the sun, its major axis cannot be shorter than the diameter of the sun, or, taking the solar radius as a unit, the quantity $2a$ can never be less than 2. The smallest velocity with which we can imagine a cosmical body to arrive on the surface of the sun is consequently

$$G\times\sqrt{\frac{1}{2}}=445{,}750,$$

or a velocity of 60 geographical miles in one second.

For this smallest value, the orbit of the asteroid is circular; for a larger value it becomes elliptical, until finally, with increasing eccentricity, when the value of $2a$ approaches infinity, the orbit becomes a parabola. In this last case the velocity is

$$G \times \sqrt{\frac{\infty - 1}{\infty}} = G,$$

or 85 geographical miles in one second.

If the value of the major axis become nagative, or the orbit assume the form of a hyperbola, the velocity may increase without end. But this could only happen when cosmical masses enter the space of the solar system with a projected velocity, or when masses, having missed the sun's surface, move into the universe and never return; hence a velocity greater than G can only be regarded as a rare exception, and we shall therefore only consider velocities comprised within the limits of 60 and 80 miles.[2]

The final velocity with which a weight moving in a straight line toward the centre of the sun arrives at the solar surface is expressed by the formula

$$c = G \times \sqrt{\frac{h-1}{h}},$$

wherein c expresses the final velocities in metres, and h the original distance from the centre of the sun in terms of solar radius. If this formula be compared with the foregoing, it will be seen that a mass which, after moving in central motion, arrives at the sun's surface has the same velocity as it would possess had it fallen perpendicularly into the sun from a distance[3] equal to the major axis of its orbit; whence it is apparent that a planet, on arriving at the sun, moves at least as quickly as a weight which falls freely towards the sun from a distance as great as the solar radius, or 96,000 geographical miles.

What thermal effect corresponds to such velocities? Is the effect sufficiently great to play an important part in the immense development of heat on the sun?

This crucial question may be easily answered by the help of the preceding considerations. According to the formula given at the end of Chapter II, the degree of heat generated by percussion is

$$= 0{\cdot}000139° \times c^2,$$

where c denotes the velocity of the striking body expressed in metres. The velocity of an asteroid when it strikes the sun measures from 445,750 to 630,400 metres; the calorific effect of

[2] The relative velocity also with which an asteroid reaches the solar surface depends in some degree on the velocity of the sun's rotation. This, however, as well as the rotary effect of the asteroid, is without moment and may be neglected.

[3] This distance is to be counted from the centre of the sun.

the percussion is consequently equal to from 27½ to 55 millions of degrees of heat.'

An asteroid, therefore, by its fall into the sun developes from 4600 to 9200 times as much heat as would be generated by the combustion of an equal mass of coal.

V. *The Origin of the Sun's Heat (continuation).*

The question why the planets move in curved orbits, one of the grandest of problems, was solved by Newton in consequence, it is believed, of his reflecting on the fall of an apple. This story is not improbable, for we are on the right track for the discovery of truth when once we clearly recognize that between great and small no qualitative but only a quantitative difference exists—when we resist the suggestions of an ever active imagination, and look for the same laws in the greatest as well as in the smallest processes of nature.

This universal range is the essence of a law of nature, and the touchstone of the correctness of human theories. We observe the fall of an apple and investigate the law which governs this phenomenon; for the earth we substitute the sun, and for the apple a planet, and thus possess ourselves of the key to the mechanics of the heavens.

As the same laws prevail in the greater as well as in the smaller processes of nature, Newton's method may be used in solving the problem of the origin of the sun's heat. We know the connection between the space through which a body falls, the velocity, the *vis viva*, and the generation of heat on the surface of this globe; if we again substitute for the earth the sun, with a mass 350,000 greater, and for a height of a few metres celestial distances, we obtain a generation of heat exceeding all terrestrial measures. And since we have sufficient reason to assume the actual existence of such mechanical processes in the heavens, we find therein the only tenable explanation of the origin of the heat of the sun.

The fact that the development of heat by mechanical means on the surface of our globe is, as a rule, not so great, and cannot be so great as the generation of the same agent by chemical means, as by combustion, follows from the laws already discussed; and this fact cannot be used as an argument against the assumption of a greater development of heat by a greater expenditure of mechanical work. It has been shown that the heat generated by a weight falling from a height of 367 metres is only $\frac{1}{3\,3\,0\,0}$th part of the heat produced by the combustion of

[' Throughout this memoir the degrees of heat are expressed in the Centigrade scale. Unless stated to the contrary, the measures of length are given in geographical miles. A geographical mile $=\frac{1}{15}$ of degree of latitude $=1878$ metres, and an English mile $=1609$ metres.]

the same weight of coal; just as small as is the amount of heat developed by a weight moving with the not inconsiderable velocity of 85 metres in one second. But, according to the laws of mechanics, the effect is proportional to the square of velocity; if, therefore, the weight move 100 times faster, or with a velocity of 8500 metres in one second, it will produce a greater effect than the combustion of an equal quantity of coal.

It is true that so great a velocity cannot be obtained by human means; everyday experience, however, shows the development of high degrees of temperature by mechanical processes.

In the common flint and steel, the particles of steel which are struck off are sufficiently heated to burn in air. A few blows directed by a skillful blacksmith with a sledge-hammer against a piece of cold metal may raise the temperature of the metal at the points of collision to redness.

The new crank of a steamer, whilst being polished by friction, becomes red-hot, several buckets of water being required to cool it down to its ordinary temperature.

When a railroad train passes with even less than its ordinary velocity along a very sharp curve of the line, sparks are observed in consequence of the friction against the rails.

One of the grandest constructions for the production of motion by human art is the channel in which the wood was allowed to glide down from the steep and lofty sides of Mount Pilatus into the plain below. This wooden channel which was built about thirty years ago by the engineer Rupp, was 9 English miles in length; the largest trees were shot down it from the top to the bottom of the mountain in about two minutes and a half. The momentum possessed by the trees on their escaping at their journey's end from the channel was sufficiently great to bury their thicker ends in the ground to the depth of from 6 to 8 metres. To prevent the wood getting too hot and taking fire, water was conducted in many places into the channel.

This stupendous mechanical process, when compared with cosmical processes on the sun appears infinitely small. In the latter case it is the mass of the sun which attracts, and in place of the height of Mount Pilatus we have distances of a hundred thousand and more miles; the amount of heat generated by cosmical falls is therefore at least 9 million times greater than in our terrestrial example.

Rays of heat on passing through glass and other transparent bodies undergo partial absorption, which differs in degree, however, according to the temperature of the source from which the heat is derived. Heat radiated from sources less warm than boiling water is almost completely stopped by thin plates of glass. As the temperature of a source of heat increases, its

rays pass more copiously through diathermic bodies. A plate of glass, for example, weakens the rays of a red-hot substance, even when the latter is placed very close to it, much more than it does those emanating at a much greater distance from a white-hot body. If the quality of the sun's rays be examined in this respect, their diathermic energy is found to be far superior to that of all artificial sources of heat. The temperature of the focus of a concave metallic reflector in which the sun's light has been collected is only diminished from one-seventh to one-eighth by the interposition of a screen of glass. If the same experiment be made with an artificial and luminous source of heat, it is found that, though the focus be very hot when the screen is away, the interposition of the latter cuts off nearly all the heat; moreover, the focus will not recover its former temperature when reflector and screen are placed sufficiently near to the source of heat to make the focus appear brighter than it did in the former position without the glass screen.

The empirical law, that the diathermic energy of heat increases with the temperature of the source from which the heat is radiated, teaches us that the sun's surface must be much hotter than the most powerful process of combustion could render it.

Other methods furnish the same conclusion. If we imagine the sun to be surrounded by a hollow sphere, it is clear that the inner surface of this sphere must receive all the heat radiated from the sun. At the distance of our globe from the sun, such a sphere would have a radius of 215 times as great, and an area 46,000 times as large as the sun himself; those luminous and calorific rays, therefore, which meet this spherical surface at right angles retain only $\frac{1}{46,000}$th part of their original intensity.

If it be further considered that our atmosphere absorbs a part of the solar rays, it is clear that the rays which reach the tropics of our earth at noonday can only possess from $\frac{1}{50,000}$th to $\frac{1}{60,000}$th of the power with which they started. These rays when gathered from a surface of from 5 to 6 square metres, and concentrated in an area of one square centimetre, would produce about the temperature which exists on the sun, a temperature more than sufficient to vaporize platinum, rhodium, and similar metals.

The radiation calculated in Chap. III. likewise proves the enormous temperature of the solar surface. From the determination mentioned therein, it follows that each square centimetre of the sun's surface loses by radiation about 80 units of heat per minute—an immense quantity in comparison with terrestrial radiation.

A correct theory of the origin of the sun's heat must explain the cause of such enormous temperatures. This explanation can be deduced from the foregoing statement. According to Pouillet, the temperature at which bodies appear intensely white-hot is

about 1500° C. The heat generated by the combustion of one kilogram of hydrogen is, as determined by Dulong, 34,500, and according to the more recent experiments of Grassi, 34,666, units of heat. One part of hydrogen combines with eight parts of oxygen to form water; hence one kilogram of these two gases mixed in this ratio would produce 3850°.

Let us now compare this heat with the amount of the same agent generated by the fall of an asteroid into the sun. Without taking into account the low specific heat of such masses when compared with that of water, we find the heat developed by the asteroid to be from 7000 to 14,000 times greater than that of the oxyhydrogen mixture. From data like these, the extraordinary diathermic energy of the sun's rays, the immense radiation from his surface, and the high temperature in the focus of the reflector are easily accounted for.

The facts above mentioned show that, unless we assume on the sun the existence of matter with unheard of chemical properties as a *deus ex machinâ*, no chemical process could maintain the present high radiation of the sun; it also follows from the above results, that the chemical nature of bodies which fall into the sun does not in the least affect our conclusions; the effect produced by the most inflammable substance would not differ by one-thousandth part from that resulting from the fall of matter possessing but feeble chemical affinities. As the brightest artificial light appears dark in comparison with the sun's light, so the mechanical processes of the heavens throw into the shade the most powerful chemical actions.

The quality of the sun's rays, as dependent on his temperature, is of the greatest importance to mankind. If the solar heat were originated by a chemical process, and amounted near its source to a temperature of a few thousand degrees, it would be possible for the light to reach us, whilst the greater part of the more important calorific rays would be absorbed by the higher strata of our atmosphere and then returned to the universe.

In consequence of the high temperature of the sun, however, our atmosphere is highly diathermic to his rays, so that the latter reach the surface of our earth and warm it. The comparatively low temperature of the terrestrial surface is the cause why the heat cannot easily radiate back through the atmosphere into the universe. The atmosphere acts, therefore, like an envelope, which is easily pierced by the solar rays, but which offers considerable resistance to the radiant heat escaping from our earth; its action resembles that of a valve which allows a liquid to pass freely in one direction, but stops the flow in the opposite.

The action of the atmosphere is of the greatest importance as regards climate and meteorological processes. It must raise the mean temperature of the earth's surface. After the setting of

the sun—in fact, in all places where his rays do not reach the surface, the temperature of the earth would soon be as low as that of the universe, if the atmosphere were removed, or if it did not exist. Even the powerful solar rays in the tropics would be unable to preserve water in its liquid state.

Between the great cold which would reign at all times and in all places, and the moderate warmth which in reality exists on our globe, intermediate temperatures may be imagined; and it is easily seen that the mean temperature would decrease if the atmosphere were to become more and more rare. Such a rarefaction of a valve-like acting atmosphere actually takes place as we ascend higher and higher above the level of the sea, and it is accordingly and necessarily accompanied by a corresponding diminution of temperature.

This well-known fact of the lower mean temperature of places of greater altitude has led to the strangest hypotheses. The sun's rays were not supposed to contain all the conditions for warming a body, but to set in motion the "substance" of heat contained in the earth. This "substance" of heat, cold when at rest, was attracted by the earth, and was therefore found in greater abundance near the centre of the globe. This view, it was thought, explained why the warming power of the sun was so much weaker at the top of a mountain than at the bottom, and why, in spite of his immense radiation, he retained his full powers.

This belief, which especially prevails amongst imperfectly informed people, and which will scarcely succumb to correct views, is directly contradicted by the excellent experiments made by Pouillet at different altitudes with the pyrheliometer. These experiments show that, everything else being equal, the generation of heat by the solar rays is more powerful in higher altitudes than near the surface of our globe, and that consequently a portion of these rays is absorbed on their passage through the atmosphere. Why, in spite of this partial absorption, the mean temperature of low altitudes is nevertheless higher than it is in more elevated positions, is explained by the fact that the atmosphere stops to a far greater degree the calorific rays emanating from the earth than it does those from the sun.

VI. *The Constancy of the Sun's Mass.*

Newton, as is well known, considered light to be the emission of luminous particles from the sun. In the continued emission of light this great philosopher saw a cause tending to diminish the solar mass; and he assumed, in order to make good this loss, comets and other cosmical masses to be continually falling into the central body.

If we express this view of Newton's in the language of the undulatory theory, which is now universally accepted, we obtain the results developed in the preceding pages. It is true that our theory does not accept a peculiar "substance" of light or of heat; nevertheless, according to it, the radiation of light and heat consists also in purely material processes, in a sort of motion, in the vibrations of ponderable resisting substances. Quiescence is darkness and death; motion is light and life.

An undulating motion proceeding from a point or a plane and excited in an unlimited medium, cannot be imagined apart from another simultaneous motion, a translation of the particles themselves;[1] it therefore follows, not only from the emission, but also from the undulatory theory, that radiation continually diminishes the mass of the sun. Why, nevertheless, the mass of the sun does not really diminish has already been stated.

The radiation of the sun is a centrifugal action equivalent to a centripetal motion.

The calorific effect of the centrifugal action of the sun can be found by direct observation; it amounts, according to Chap. III, in one minute to 12,650 millions of cubic miles of heat, or 5·17 quadrillions of units of heat. In Chapter IV it has been shown that one kilogram of the mass of an asteroid originates from 27·5 to 55 millions of units of heat; the quantity of cosmical masses, therefore, which falls every minute into the sun amounts to from 94,000 to 188,000 billions of kilograms.

To obtain this remarkable result, we made use of a method which is common in physical inquiries. Observation of the moon's motion reveals to us the external form of the earth. The physicist determines with the torsion-balance the weight of a planet, just as a merchant finds the weight of a parcel of goods, whilst the pendulum has become a magic power in the hands of the geologist, enabling him to discover cavities in the bowels of the earth. Our case is similar to these. By observation and calculation of the velocity of sound in our atmosphere, we obtain the ratio of the specific heat of air under constant pressure and under constant volume, and by the help of this number we determine the quantity of heat generated by mechanical work. The heat which arrives from the sun in a given time on a small surface of our globe serves as a basis for the calculation of the whole radiating effect of the sun; and the result of a series of observations and well-founded conclusions is the quantitative determination of those cosmical masses which the sun receives from the space through which he sends forth his rays.

Measured by terrestrial standards, the ascertained number of so many billions of kilograms per minute appears incredible.

[1] This centrifugal motion is perhaps the cause of the repulsion of the tails on comets when in the neighborhood of the sun, as observed by Bessel.

This quantity, however, may be brought nearer to our comprehension by comparison with other cosmical magnitudes. The nearest celestial body to us (the moon) has a mass of about 90,000 trillions of kilograms, and it would therefore cover the expenditure of the sun for from one to two years. The mass of the earth would afford nourishment to the sun for a period of from 60 to 120 years.

To facilitate the appreciation of the masses and the distances occurring in the planetary system, Herschel draws the following picture. Let the sun be represented by a globe 1 metre in diameter. The nearest planet (Mercury) will be about as large as a pepper-corn, $3\frac{1}{2}$ millimetres in thickness, at a distance of 40 metres. 78 and 107 metres distant from the sun will move Venus and the Earth, each 9 millimetres in diameter, or a little larger than a pea. Not much more than a quarter of a metre from the Earth will be the Moon, the size of a mustard seed, $2\frac{1}{2}$ millimetres in diameter. Mars, at a distance of 160 metres, will have about half the diameter of the Earth; and the smaller planets (Vesta, Hebe, Astrea, Juno, Pallas, Ceres, &c.), at a distance of from 250 to 300 metres from the sun, will resemble particles of sand. Jupiter and Saturn, 560 and 1000 metres distant from the centre, will be represented by oranges, 10 and 9 centimetres in diameter. Uranus, of the size of a nut 4 centimetres across, will be 2000 metres; and Neptune, as large as an apple 6 centimetres in diameter, will be nearly twice as distant, or about half a geographical mile away from the sun. From Neptune to the nearest fixed star will be more than 2000 geographical miles.

To complete this picture, it is necessary to imagine finely divided matter grouped in a diversified manner, moving slowly and gradually towards the large central globe, and on its arrival attaching itself thereto; this matter, when favorably illuminated by the sun, represents itself to us as the zodiacal light. This nebulous substance forms also an important part of a creation in which nothing is by chance, but wherein all is arranged with Divine foresight and wisdom.

[To be continued.]

ART. XVI.—*Second Notice of Recent Researches relating to Nebulæ;* by A. GAUTIER.[1]

Labors of Lord Rosse; First Memoirs.—Since 1827 Lord Rosse has been engaged in the construction of large specula for astronomical telescopes. In 1839 he finished his first telescope, which had a speculum three feet in diameter with a focal distance of 27 feet, and he described the method of constructing it in a me-

[1] Translated for this Journal from the *Bibliothèque Universelle*, for June, 1863.

moir which was inserted in the *Philosophical Transactions* of the Royal Society of London for the year 1840. Afterwards, he undertook to produce specula of larger dimensions, and in 1844 he completed two, six feet in diameter, with a focal distance of 56 feet, for the employment of which he constructed a huge telescope, which he erected in the open air, between two walls to which it was attached, near his country seat at Birr (Castle) or Parsonstown in Ireland, twenty-five leagues southwest of Dublin.

Lord Rosse has been for several years President of the Royal Society of London. In 1850 he published in the Transactions of this ancient and illustrious Society, his first memoir of 15 pages quarto upon his observations of nebulæ, accompanied with four plates representing seventeen of these celestial objects. Before noticing his second memoir upon the same subject, presented to the same Society in 1861, I will mention some details extracted from the preceding memoir.

In the memoir of 1850, Lord Rosse first pointed out the spiral form which he had discovered in many nebulæ, a fact of great importance as throwing new light upon the constitution of those celestial systems.

The beautiful nebula, No. 51 of Messier's catalogue, (No. 1622 of the catalogue published by Sir John Herschel, in the *Phil. Trans.* for 1833,) is situated in the constellation *Canes Venatici*, near *Bootes*, in about $13^h\ 23^m$ of right ascension and 48° of north declination. It had been described by Messier as a double nebula containing stars; by Sir William Herschel as a brilliant nebula surrounded at a little distance by a sort of halo or glory, and having a companion near. Sir John Herschel had further observed the division of the southwest border of the annulus into two branches. Lord Rosse, in 1845, was the first to discover the spiral structure forming many circumvolutions without curves returning regularly upon themselves. The sketch which he gave from many observations with the telescope of six feet diameter presents a dozen distinct circumvolutions more or less extended.

"We see," said this astronomer, "that every step of progress in optics exhibits a more complicated structure in this nebula, and it is more and more difficult to explain it by the dynamical laws which prevail in our solar system. The second nebula is evidently connected with the larger one, but the form of the nebula being such as is represented in the figure, this connection increases the difficulty of conceiving of any hypothesis to explain it. It appears in the highest degree improbable that such a system exists without interior movement. It is possible to unite to this idea that of a resisting medium, but the supposition of an equilibrium purely statical is not admissible. Some posi-

tive measurements, whether of changes of brightness, or of form, or of variations of position, will therefore be most highly interesting, but they present great difficulties." Mr. Johnston Stoney, whom Lord Rosse associated with himself in these observations, meanwhile, in the spring of 1849 and 1850, made micrometric measurements, assigning in the present memoir the relative positions of different stars situated in the nebula, No. 51 of Messier, as referred to its central nucleus. The nebula No. 99 of Messier, (No. 1173 of Sir John Herschel's catalogue,) situated about $12^h\ 10^m$ of right ascension and 15° of northern declination, has also given opportunity for some similar measurements. This is the second nebula in which Lord Rosse has shown a very distinct spiral structure. He has described also, in his memoir of 1850, twelve fainter nebulæ of the same class, and he surmised that some others are of the same kind. He described and figured in this memoir five new annular nebulæ, in addition to the two already contained in the catalogue of Sir John Herschel; also some more stars called nebulous, and other nebulæ of an elongated lenticular form, three of which are represented in the plates attached to this memoir.

The Latest Memoir of Lord Rosse.—The new memoir presented by Lord Rosse to the Royal Society of London in June 1861, and which appeared in 1862, in Part III of the Philosophical Transactions for 1861, consists of 65 pages quarto. It is accompanied by seven plates, one of which is devoted to the telescope of six feet aperture, while the others represent 43 nebulæ. This memoir is the result of seven years' observations made with his great telescope; but, as Lord Rosse remarks, in a climate so foggy as Ireland the labor of a year, measured by the number of hours in which it is possible to make good observations of nebulæ, is not considerable.

"Here," he says, "in winter celestial objects are usually most distinct, and the sky is the darkest before eleven o'clock at night; the sky however soon becomes luminous and the details of the nebulæ which are less distinct disappear. In spring and autumn the change of light is not so prompt nor so decided, but the nights are shorter. Guided by the admirable catalogue of Sir John Herschel (containing the positions and a summary description of 2306 nebulæ) we have examined nearly all the more brilliant nebulæ known, with the exception of a few in the vicinity of the pole, and have observed a great part of the fainter ones. We have not especially sought for new nebulæ, but yet meanwhile many such have been accidentally discovered in the immediate neighborhood of nebulæ already well known, but they are for the most part very faint objects presenting little interest. In all cases where any peculiarity has been discovered, such, for example, as a spiral curvature, lines or dark spaces, a sketch has been made, and the most remarkable objects have been submitted to a detailed examination, on favorable nights, sometimes with the aid of a micrometer. In our eminently variable climate, when we em-

ploy high magnifying powers and large apertures, vision is more or less altered, either by the tremor of the air, or by the vapor, and the state of the air varies enormously, in both these respects, from one night to another, and even from hour to hour. Neither is the performance of the speculum uniform. Sudden alterations of temperature in this humid climate produce deposits of dew, and the speculum gradually becomes tarnished. It is possible to remedy this by artificial heating, but that would produce other difficulties and we have not had recourse to that expedient. It is thus difficult to say that any celestial object has been examined under circumstances altogether favorable. Nevertheless as it is not probable that we should be able to add much to the details already obtained with the nebulæ, unless it be under conditions of the atmosphere particularly advantageous and very rare, I have decided not to defer longer the presentation of this memoir."

The author begins with numerous details of the processes adopted for casting and polishing large specula as well as the method adopted for mounting them. As I have previously had occasion to mention it in my Notice of 1845, I will not follow out this subject, which has more interest and importance for makers of instruments of this kind than for the public.

I will merely mention that the specula made by Lord Rosse are formed of an alloy of a little more than two parts of copper to one part of tin, the specific gravity of the alloy being 8·8. The mirrors of three feet in diameter weigh about 1200 French pounds, and those of six feet diameter weigh 4 tons or 8000 pounds. The mounting is not equatorial and the telescope does not move very much from the meridian. In order to be able to use it constantly it is convenient to have two specula to be used alternately. Lord Rosse has made use of the Newtonian form, employing a small reflecting mirror, inclined at an angle of 45°, which permits the observer to place himself at one side of the instrument with an eyepiece. He estimates that a linear magnifying power of about 1300 times is the largest that can generally be used with advantage in his telescopes, for the observation of nebulæ; but he has occasionally made use of a power of more than 2000 times for discovering small stars with the telescope of 3 feet aperture. On some occasions the 6 feet reflector has admitted even more than this; but in the climate of Ireland those occasions are rare and of short duration. The author thinks that telescopes of even greater dimensions may be constructed and employed with advantage in favorable climates, for studying the details of nebulæ of feeble light, as well as to recognize a great number that are double or multiple. He also thinks that it would be well to employ silver for the second reflection. Lord Rosse says he has often experienced much difficulty in choosing between numerous observations, in view of the uncertainty which sometimes exists in regard to the reality of a fact, presented sometimes in one way and sometimes in another, accord-

ing to the time of observation. He is disposed in general rather to describe in detail the parts of nebulæ of feeble light than to determine their resolvability into stars. He has made use successively of many mirrors of six feet diameter two or three of which have been as perfect as the first; but, considering the hard labor required for removing and repolishing such large specula, he acknowledges that a considerable mass of observations have been made with mirrors in a condition evidently imperfect. He has frequently been able to show, with a telescope of three feet diameter, a case of resolvability, while no trace of this kind has been perceived by the telescope of six feet aperture in its ordinary condition. Questions relating to the structure of the nuclei of nebulæ furnish remarkable analogies. When they have such nuclei they present sometimes a gentle and sometimes a rapid increase of light towards the centre, and they sometimes manifest at this point a stellar appearance which might be considered as a real star; but the impressions made upon the eye at the moment of observation cannot be admitted in all cases as real physical facts. The author thinks it proper however to make the following remark. Among the Clusters there may be some, placed at a great distance or examined with an instrument of insufficient optical power, which may be regarded as nebulæ with centres of light or of different condensation; but there does not appear to be any cluster having a central star of such great brilliancy that it could under all circumstances be arranged in the class of objects having a star at the centre.

Lord Rosse has made observations in connection with the brothers Johnston and Bindon Stoney, and more recently with Mr. Mitchell; the greater part of these observations have been made in his absence, but in his opinion they are worthy of none the less confidence. Each of these gentlemen has made observations for about two years, and has made elaborate drawings of some remakable nebulæ. Bindon Stoney, in 1850 and 1851, made micrometer measurements of nebulæ Nos. 1622 and 2060 of Sir John Herschel's catalogue. The comparison of the results with those obtained by Otto Struve and communicated by him to Lord Rosse, in a letter dated at Poulkova, June 2d, 1851, and inserted in the memoir under consideration, present an accordance generally satisfactory. Lord Rosse regrets not having engaged Mr. Mitchell, who has been charged with these observations since the month of May, 1852, to continue the micrometer measurements, the arrangement of the materials of his last memoir giving him occasion to suspect some changes in the direction of certain parts of the nebulæ, especially in that of No. 1905 of Herschel's catalogue.

The second part of this memoir is composed of a brief *résumé* of observations descriptive of the greater part of the nebulæ of

Sir John Herschel's catalogue of 1833, arranged in the order adopted by that catalogue, that is, according to their right ascensions. These observations are frequently accompanied, in the text itself, by designs rapidly executed upon wood, representing the characteristics of some of the nebulæ, among which are fifteen having a structure distinctly spiral.

The memoir is concluded with a list of thirty-five nebulæ of Herschel's catalogue which have not been rediscovered in the course of the ordinary observations of Lord Rosse and his assistants, and to which it is therefore desirable that the attention of astronomers should be directed anew.

The drawings of remarkable nebulæ have been very faithfully engraved by Mr. Basire, as were those of the first memoir. Lord Rosse observes however that the stars are frequently figured too large.

From the preceding analysis it appears that the last memoir of Lord Rosse, without presenting any very remarkable new facts, has considerable importance as completing the researches upon nebulæ visible in Ireland, undertaken by him and his assistants. We must admire the persevering energy displayed by Lord Rosse, in such a social position as his, whether in the construction of his great telescopes, or in employing them to the best advantage, as well as the candor with which he has described in detail his processes of construction, and pointed out the imperfections which may be noticed in observations of so difficult and delicate a character in such a cloudy climate.

Lord Rosse agrees fully, in his appreciation of the great difficulties to which the observation of nebulæ give rise, with the two astronomers who have recently been engaged with him—Messrs. Otto Struve and D'Arrest, as may be seen in the brief notice of their labors which I inserted in the *Archives* for September, 1862.

It does not appear that the observations thus far confirm the ideas, previously put forth by some savans, as to the probability of a gradual process of concentration of the luminous matter in these celestial objects. The spiral structure of a goodly number of nebulæ accords but little with these ideas. Lord Rosse remarks, in his first memoir upon this subject, that this structure seems to indicate the presence of dynamical laws, to the determination of which we may at length arrive; but he does not think that in the actual state of our knowledge it is possible to form even plausible conjectures of this kind, and the more he has observed the more this investigation has appeared to him mysterious and unapproachable.

II. *Various Announcements and Articles relating to Nebulæ.*—Mr. D'Arrest has announced, in No. 1379 of the *Astr. Nachrichten*, the existence of a third variable nebula, north of the constellation Taurus. This nebula had been seen before at the observa-

tory of Bonn, by Messrs. Schönfeld and Krüger, in 1855 and 1856, and in America, by Mr. Tuttle, in 1859. It was then visible with a comet seeker of 34 lines aperture, but in 1862 Mr. D'Arrest found that it was seen with difficulty at Copenhagen with the great telescope of his observatory.

Mr. Schönfeld, acting director of the observatory of Mannheim, published in No. 1391 of the *Astr. Nachrichten* a notice of the observations upon nebulæ recorded in the surveys of the heavens by zones made at the observatory of Bonn, in which he denies the variability of the light of this same nebula of Taurus, which he had observed without difficulty, in September, 1862, with a telescope of eight feet focal length. The author regards the variability of the second nebula of this kind in Taurus as no more certain than that of the one discovered in 1855 by Mr. Tempel, in the Pleiades, near the star Merope, and designated as variable by Mr. D'Arrest, in No. 1378 of the *Astr. Nachrichten*, Messrs. Chacornac having also observed it with him, in September, 1862. Mr. Schönfeld considers that the variability of the atmosphere and of the eye of the observer may occasion very different impressions from nebulæ of feeble and somewhat diffused light.

Doctor Auwers, astronomer at Göttingen, in a letter which follows the preceding article, takes the same view as Mr. Schönfeld. From his own observations, made at Königsberg in 1858, and at Göttingen in 1861, he admits indeed the variability of the light of the nebula discovered in Taurus by Mr. Hind in 1852, which appears to have attained its greatest brilliancy in 1856, and to have disappeared in 1860, but he does not credit the variability of the other two nebulæ in Taurus. He says, "I have frequently observed, among other occasions at one of the appearances of Encke's comet, that celestial objects somewhat extended, with feeble and diffused light, are more easily recognized with small optical instruments than with the larger ones, the field of vision of these last being in general quite limited." He adds that in September, 1862, he clearly distinguished the two nebulæ in question, with a comet seeker of two feet focal length.

Dr. Auwers has also inserted in No. 1392, *Astr. Nachr.*, a catalogue of the exact positions in 1860 of forty nebulæ as observed with the heliometer of the observatory of Königsberg. This catalogue is accompanied with various remarks, and the comparison of the positions given with those of the same nebulæ in the catalogues already published by Messrs. Langier and D'Arrest. These comparisons do not appear to show any changes of position.

Doctor Winnecke, in a letter dated at the Observatory of Poulkova and inserted in No. 1397 of *Ast. Nachr.*, confirms the opinion announced above, that small telescopes frequently enable us

to distinguish nebulæ better than the larger instruments. He does not think the variability of the last two nebulæ of Taurus has been distinctly shown.

Mr. D'Arrest, in an article published in No. 1393 *Astr. Nachr.*, acknowledges the variability of the nebula near Merope, and points out another nebula marked by Jeaurat to the north of Pleïone, in a chart of the Pleiades published by him in the *Mémoires de l'Académie des Sciences* of Paris, for 1779, which has not yet been rediscovered. He presumes, therefore, that this region of the heavens is especially subject to variations of light.

The same astronomer has announced, in No. 1407 *Astr. Nachr.*, that Sir John Herschel is preparing a new general catalogue of nebulæ from observations both ancient and modern, and he gives on this occasion a list of corrections of the catalogue of 1833, resulting from his own observations and those of Messrs. Auwers and Marth, which Sir John Herschel will be able to make use of in his new work.

The later numbers of the *Monthly Notices* of the Astronomical Society of London contain no articles relating to nebulæ. I will cite only one article by F. Abbott, dated at his private observatory at Hobart-Town, (Australia,) in May, 1862, and published in the *Monthly Notices*, No. 1, Vol. 23, page 32. This article, presented to the Society at its session Nov. 14, 1862, with a drawing which has not been reproduced in the *Monthly Notices*, is devoted to a cluster of stars in the Southern Cross designated by the Greek letter *Kappa*. "This beautiful cluster," says Mr. Abbott, "which Sir John Herschel stated to be composed of 50 or 100 stars of different colors is scarcely visible with the naked eye; but viewed with a telescope it is one of the most brilliant and interesting objects in the southern heavens, not only for the extreme beauty of color and arrangement which distinguish it, but also for certain changes which appear to have taken place in the number, position and color, of the stars which compose it, since it was observed at Feldhausen, near the Cape of Good Hope, by Sir John Herschel, about the year 1835."

The seventy-five stars found in the drawing of Mr. Abbott have been observed and their positions determined by him, either with a telescope of five feet focal length, furnished with an excellent achromatic object glass of $4\frac{1}{4}$ inches diameter, or with an achromatic telescope of seven feet, made by Dolland. The magnifying power employed for determining their positions was one hundred and thirty-five, and that for the colors only twenty-seven diameters. Many of the stars appear to have changed their positions, and a considerable number of those figured in the drawing of Mr. Abbott are not found in the description and representation made by Sir John Herschel.

Several of the stars have preserved their color, but according to Mr. Abbott, most of them have changed; all the small stars, from the tenth to the fourteenth magnitude, have the color of Prussian blue, with more or less of a tint of red or green mixed with the blue.

Mr. Bond, of Cambridge, U. S., continues his observations upon nebulæ. According to a note added to the English translation of my review of this subject, in September, 1862, (published in the *American Journal of Science*, for January, 1863,) this astronomer is now preparing to publish a complete account of fourteen years observations upon the nebula of Orion made with the telescope of Harvard College; and the comparisons which will result will very probably furnish new and interesting remarks. In another note, the editors of the *American Journal* say that they are authorized to state, contrary to an assertion of Otto Struve, reported in my Notice, that Mr. Bond has distinctly recognized and recorded, in five original sketches drawn in 1847 and 1848, the *nebulous bridge*, situated upon the *Sinus Magnus* in one of the regions of the nebula of Orion, and that this bridge is figured in most of his more recent sketches.

No. 1383, *Astr. Nachr.*, contains a new plate upon a small scale of this same nebula of Orion, and also numerous stars situated upon and around it, drawn in 1861, by W. Tempel, from his own observations made with a telescope of four inches aperture, with magnifying powers of only 20 to 40 diameters.

Finally, I will report a note by Chacornac, entitled "*Nébuleuse variable de ζ du Taureau*," presented by Mr. Le Verrier to the Academy of Sciences of Paris at its session April 6, 1863, and inserted in the *Comptes Rendu* of that meeting, t. 56, p. 637.

Mr. Chacornac, at Marseilles, in the latter part of 1853 and the first part of 1854, noticed a star of the eleventh magnitude situated at about $5^h\ 28\frac{1}{2}^m$ of right ascension and 21° 7′ of northern declination, without perceiving any nebula at that point; but he could not see any at Paris near the meridian towards the end of 1854, with a telescope of twenty-five centimeters aperture, although the atmosphere was very transparent.

The 19th of October, 1855, he observed a faint nebula projecting itself upon this same small star very near to ζ of Taurus. November 10th, the nebula had changed neither its place, dimensions, or form. January 27th, 1856, it appeared to him quite brilliant, presenting the appearance of a transparent cloud which seemed to reflect the light of ζ of Taurus; its appearance, totally different from that of the nebula No. 357, (Herschel, 2,) gave no idea of stellar points visible throughout the whole extent of its surface. It was like a light *cirro-stratus*, striped with parallel bands, presenting a form nearly rectangular, the greater side of which measured an arc of $3\frac{1}{2}$ minutes, and the smaller arc $2\frac{1}{2}$ minutes.

November 20th, 1862, Mr. Chacornac could no longer find the least trace of this nebula, while the small star upon which it was projected did not present any variation of brightness; and the nebula has since been invisible with the instruments of the Imperial Observatory of Paris.

We see by the preceding Notices what a degree of activity and interest the researches upon nebulæ now inspire, and also how many difficulties they present. It will not probably be very long before we may hope to obtain a solution of some of the important questions to which they have given rise.

ART. XVIII.—*On the action of very weak Electric Light on the Iodized Plate;* by OGDEN N. ROOD, Professor of Physics in Columbia College.

ABOUT three years ago Dove received from Mr. Gunther of Berlin a photograph of a bronze statue of an amazon holding a lance in a perpendicular position, Mr. G. at the same time calling his attention to a singular mark in the picture, which was not in the original. The lance was properly delineated on the negative plate, but in addition, just at its tip, a dark streak was visible, though nothing of the kind had been observed at the time of taking the picture. Careful examination of the plate showed two other analogous marks. Dove thought that these singular appearances might have been caused by the presence of invisible electric brushes, resting on these points, and undertook some experiments to determine whether weak electric light could be photographed. Geisler tubes were used in a *dark* room, and with the aid of Gunther, he succeeded in obtaining good photographs of the stratified discharge,[1] as Prof. Wm. B. Rogers[2] had done some months previously.

This led me to attempt the study of the *electric brush* by the aid of photography, but as its light is incomparably weaker than that from a Geisler tube, I found that no impression was produced on the sensitive plate. Being unwilling to abandon the matter, a very sensitive collodion was then prepared from pyroxyline, in which the cotton fibre was somewhat disintegrated, and by its use I finally obtained good photographs of the positive, as well as of the negative brush. An ordinary camera was employed, and the exposure lasted seven minutes. The minute photographs were then enlarged as usual, and prints made from the enlarged negatives.

[1] Pogg. Annalen, vol. cxiii, No. vii.

[2] This Journal, xxx, 387.

The positive electrical brush consists, as is well known, of a short stem with widely branching ramifications; these latter are very faint even in the darkest room, and failed to produce an impression on the plate. The stem of the brush, which is somewhat more luminous, delineated itself as represented on the wood-cut, fig. 1, which is from a photograph magnified ten diameters.

1.

Positive electric brush.

2.

Negative electric brush.

It is well known that the negative brush is much smaller than the positive, and it is often spoken of as a star or minute point of light; the photograph, however, shows that this is not the case, but that its structure is analogous to that of the positive brush, only that the ramification begins lower down on the stem, as it were, nearly at its root, as is seen in the wood-cut, fig. 2, which is from a magnified photograph.

Action of weak electric light on the plate in the presence of daylight.—The Geisler tubes in the physical cabinet of the college enabled me now to put the probability of Dove's suggestion to the test of experiment; some of these were connected with an induction coil and photographed in broad daylight, when it was found that the image formed by the electric discharge could be easily traced through the length of the tubes, and that even the stratification was still partially visible. In these cases, however, the electric light was still visible to the eye during the discharges.

Accordingly, to make an exact experiment on this point, a sheet of white paper was placed behind one of these tubes and white daylight reflected through it towards the camera. The intensity of this reflected light was so regulated that the bright envelope of the platinum wire was nearly invisible, and the diffused violet light, at a greater distance from the wire, *absolutely* invisible. Nevertheless an intense photographic image of the envelope, and a very distinct image of the diffused electric light was easily obtained, thus proving conclusively the correctness of Dove's assumption, that electric light, which in ordinary daylight could not be seen, owing to its feeble illuminating power, might yet make itself very evident on the iodized plate, by virtue of its high percentage of chemical rays.

This experiment is indeed a very striking proof of the chemical activity of the electric light, the more so, as according to some of my experiments, the iodized plate is by no means as sensitive to slight differences in illumination as the human eye.

Among the Geisler tubes belonging to the college I found one in which bulbs of uranium glass were alternated with small tubes of plain colorless glass. When the room was darkened, and the electric discharge passed through it, owing to their fluorescence the balls shone very brightly, invisible or faintly visible light being converted into bright green light. On taking a photograph of the tube, it was quite surprising to see how blank were the spaces on the plate, where the images of the green bulbs had fallen; after an exposure of four minutes only one of the bulbs could be faintly traced, though other portions of the discharge were represented by an intense deposit of silver. This shows how completely the electric light is divested of its chemical power by dispersion from a thin stratum of this kind of glass.

It might be supposed that uranium glass would cut off most of the chemical rays, when ordinary daylight was *transmitted* through it, but this was not found to be the case. I placed the Geisler tube with the uranium bulbs, so that the light from a bright sky fell directly through it on the lens of the camera, the entire aperture of the lens (a "portrait combination" of six inches focal length) was used, and the exposure lasted one minute. An examination of the negative plate showed that the thin walls of the uranium bulbs had merely *diminished* to some extent the chemical power of the rays passing through them. The same experiment with a plate of uranium glass two-tenths of an inch in thickness gave a result like in kind only differing in degree: the chemical intensity of the light being diminished about one-half. This shows, in accordance with theory, that it is mainly the *dispersed* light which has lost its chemical power, and that through a plate of even this thickness many chemical rays still penetrate.

A photograph of another Geisler tube, in which the interior discharge tube was surrounded by a solution of sulphate of quinine, was also taken: this liquid by its fluorescent property diminished, of course, the intensity of chemical action of the electric light, but by no means to the same extent as the uranium glass.

Feb. 3d, 1864.

Art. XIX.—*On the Invisibility of Nebulous Matter;* by D. Trowbridge.

It has generally been supposed that if nebulous matter, in the proper sense of the word, or cosmical vapor, exists in the heavens, and within reach of our telescopes, it will be visible to the eye, with suitable optical aid. It is proposed to show in this article, with some plausibility, that this is an erroneous idea, except in some particular cases.

Comets are the only celestial objects, whose physical constitution is approximately understood, that afford us anything like a distinct notion of what nebulous matter is. By far the greater proportion of these bodies are composed of materials so extremely rare that the solar rays can penetrate completely through the denser portion of their bodies, and the light in some cases seems to suffer scarcely any diminution in intensity. Yet these bodies, which perhaps would weigh at the surface of the earth but a few ounces, or but a few pounds, are distinctly visible with the smallest optical aid, and even, under favorable circumstances, with the naked eye. Sir John Herschel says, of this class of comets, that the most unsubstantial clouds which float in the higher regions of our atmosphere, must be looked upon as dense and massive bodies in comparison with the almost spiritual texture of these light bodies. A cloud composed of materials so rare, and whose distance from us did not exceed fifteen or twenty miles, would scarcely be visible. A comet, however, will be visible when its distance from us is many millions of miles.

What conclusion can we draw from these facts? Do they not indicate that comets do not shine wholly by reflected light? On the 3d of July, 1819, Arago made an attempt to analyze the light of comets, by applying his polariscope to the great comet of 1819. The instrument showed unmistakable signs of polarized light, and, therefore, of reflected sun-light. Similar observations on Halley's comet, in 1835, more clearly indicated the existence of polarized light. "These beautiful experiments still leave it undecided, whether, in addition to this reflected solar light, comets may not have light of their own. Even in the case of the planets, as, for instance, in Venus, an evolution of independent light seems very probable."[1]

"The variable intensity of light in comets cannot always be explained by the position of their orbits, and their distance from the sun."[2] After mentioning Arago's observations, with his polariscope, on Halley's comet, in 1835, Mr. Hind says, "Still the variation in the intensity of light is not universally such as should follow if the comet merely reflected the sun's rays under

[1] Cosmos, vol. i, pp. 90, 91. Bohn's edition. [2] Cosmos, vol. i, p. 91.

certain permanent conditions, and we are under the necessity of looking to physical causes inherent in the body itself for an explanation of some few observations which appear irreconcilable with the theory of reflected solar light."[3] "The molecular conditions of the head or nucleus, so seldom possessing a definite outline, as well as the tail of the comet, is rendered so much the more mysterious from the fact that it causes no refraction."[4]

I have collected these facts together to show that reflected solar light cannot completely explain, at present, all the phenomena of the light of comets. Besides the above observations, it may be added that the visibility of comets in the day time, and even when near the sun, also indicates a light-generating process in the comet; for otherwise we must suppose them capable of reflecting more light than the planets. Indeed, it is difficult to see how a body can maintain its gaseous or nebulous state without being kept at a high temperature, and therefore, having within itself a light-producing cause. Assuming, then, that there is a light-generating process that is active in comets, let us see what use can be made of it, and whether it will afford us any light on the subject of the visibility of nebulous matter.

It is now a well-established fact that the heads of comets contract in dimensions as they approach the sun. This was first noticed by Hevelius, but was not established till many years afterwards. What is the cause of this condensation of cometary matter as the comet approaches the sun? Whatever may be the cause of it, we know that it has a great effect on the visibility of the comet. Is it not possible that the solar rays, acting chemically or otherwise, excites in the comet those principles which cause it to send out in greater abundance, direct light? We know that a comet will increase in brightness with great rapidity as it approaches the sun; and also decrease in brilliancy with equal rapidity in general, as it recedes from the sun, so that the fainter comets disappear in the best telescopes, when, their apparent dimensions only being considered, they ought to remain visible. The dilatation of the cometary volume seems to prevent the comet from sending out much light, either reflected or direct.

Applying these principles to *nebulæ* proper, we must conclude that nebulous vapor is necessarily too diffuse, has too little density to be visible, when far removed from us. According to this, then, nebulæ cannot in general be visible, unless they are considerably condensed, and perhaps actually converted into stars. It is perfectly evident that the luminosity of nebulous vapor must be very feeble, even where the light is inherent. The process of condensation only, then, can render nebulous matter visible through our telescopes. Will not this account for the fact that

[3] Hind's Treatise on Comets, p. 24.

[4] Cosmos, vol. iv, p. 548.

higher telescopic power resolves *previous* nebulæ? It is very doubtful whether our best telescopes will ever be able to bring into view any real nebulæ. According to the Nebular Hypothesis, we should not expect to find any large collection of nebulous matter in the vicinity of our system, either planetary or stellar, and ages may pass before our system, in its progress through space, will come near any of the small patches that may exist, so as to render them visible to us.

Perry City, N. Y., Aug. 31st, 1863.

Note.—The influence of the magnetic power of the sun, may be a potent cause to render comets visible as they approach the great central luminary. It is a fact derived from observation, that the sun affects the magnetic needle, and that its period is closely connected with the period of the solar spots. It is also known that the *auroras* influence the needle; and that they are subject to the same law of periodicity as the solar spots, and thus seem to be connected with solar influence. The effect of the auroras is evidently light-producing.

ART. XX.—*Remarks on the family Pteriidæ, (=Aviculidæ) with descriptions of some new fossil genera;* by F. B. MEEK.

THE existing genera of the family Pteriidæ form a group at once so natural, and so distinctly defined, that conchologists meet with little difficulty in deciding what particular genera it should include.[1] When we undertake to classify the more numerous extinct genera, however, which were introduced, lived out their term, and passed out of existence at various periods during the immense interval of time between the first introduction of this type of life and our present epoch, the case is very different; for we find amongst the vast numbers of fossil species, types presenting various intermediate gradations between the modern

[1] Perhaps the only question in regard to the limits of this family, as known in our existing seas, respecting which late writers on conchology differ, is, whether or not it should include the *Pinna* group. Some think it should, while others make a distinct family for the reception of *Atrina* and *Pinna*. The latter view seems to be more nearly correct; but whether we view the group as a family or a subfamily, it should probably include the Jurassic genus *Trichites*. There is also a curious Permian genus that may belong here. Its type is *Pinna prisca*, Munster, = *Avicula pinnæformis*, Geinitz, (*Dyas*, p. 77, pl. xiv, fig. 1, 2, 3, 4). For this genus I would propose the name, AVICULOPINNA.

The typical species is an elongated, thin, nearly or quite equivalve shell, with the narrow tapering general form, and very long hinge line of *Pinna*;—from which it differs in not having its beaks terminal, but set back some distance from the rather obtusely pointed anterior extremity. The beaks, however, are depressed and scarcely distinct from the cardinal margin, and the general aspect of the shell seems to be intermediate between that of *Pinna*, and *Avicula Modiola*. It would be interesting to know whether or not it has a prismatic structure; if not, it will most probably be found to belong to the *Mytilidæ*.

representatives of this and some of the allied groups.[1] For instance, no conchologist could be for a moment in doubt whether any particular species or genus of our existing Mollusks belongs more properly to the *Aviculidæ* or to the *Pectenidæ*. Yet in tracing these two families by their fossil shells back into the distant past, we meet with various types presenting such an assemblage of characters as to often render their proper distribution more difficult; especially since we have only the light of analogy to guide us in our conclusions respecting the structure of the softer parts of these extinct forms. Some of these peculiar species were formerly referred by many paleontologists to the genus *Pecten*, and by others to *Avicula;* and even now, since the genus *Aviculopecten* has been established for their reception, authors are by no means agreed whether this genus should be classed with the *Pectenidæ* or the *Aviculidæ*.

Again, no one having even a small amount of conchological knowledge need be at a loss in deciding to which of the two families, *Arcidæ* or *Aviculidæ*, any of our existing species of bivalves properly belong. Yet in passing from group to group of the *Arcidæ*, from the recent typical examples, through some of the other modern forms, and thence through various extinct types, it will be observed that the hinge plates, or denticles, become more and more oblique, until in some of the Paleozoic genera, such as *Cyrtodonta*, *Vanuxemia*, *Dolabra*,[2] &c., only a few obscure divisions are to be seen at the remotest extremities of the hinge, ranging nearly or quite parallel to the cardinal margin, as in *Pterinia*, *Bakevellia*, and some of the other genera apparently belonging to the *Aviculidæ*. In addition to this, in many of the extinct groups of *Aviculidæ*, such for instance as *Gryphorhynchus*, *Myalina*, *Bakevellia*, &c., there is as well a developed cardinal area, as we generally see in the *Arcidæ;* while this area, in several of these ancient types, is provided with cartilage furrows, as in the *Arcidæ*. Again, in *Pterinia*, and some species of *Bakevellia*, we see the anterior muscular impression comparatively so well developed, that one can scarcely believe it was not made by a true adductor; while the eccentric position of the posterior muscular impression would seem also to favor the same conclusion; and yet in all their other known characters these forms agree with the *Aviculidæ*.

In another direction, some of these ancient groups of *Aviculidæ*

[1] Whether the introduction, and gradual dying out of the various forms presenting these intermediate characters resulted from the operation of a law of nature, like that termed by Dr. Darwin "natural selection," or any other, or from repeated miraculous creations, it is not the object of this paper to discuss.

[2] As typified by *Cucullæa angusta* Sowerby, which must now be regarded as the type of *Dolabra*, since Prof. King has separated from that genus as first proposed, the genus *Schizodus*. *Dolabra? alpina* Hall, (Iowa Report, i, part ii, pl. 29 fig. 2) is a *Schizodus*.

seem to show a disposition to shade off towards the *Mytilidæ* or *Dreissenidæ*. Amongst the Carboniferous and Permian species of *Myalina*, for instance, we see species presenting exactly the form and other general external appearances of the existing genera *Mytilus* and *Dreissena*, to which even yet some paleontologists will persist in referring them. On a closer inspection, however, these Carboniferous and Permian species, when we can find them with the two valves united, are seen to be always a little inequivalve, while their hinge also differs from that of the *Mytilidæ* and *Dreissenidæ* in having a flat area with longitudinal cartilage furrows. In addition to these differences, I have discovered that the shell structure of at least two species of *Myalina*, (*M. perattennuata* Meek & Hayden, and *M. angulata* Meek & Worthen,) is minutely prismatic, like the outer portion of the shell in the true *Aviculas*. It is true that the same structure has also been observed by Dr. Carpenter in the inner layer of *Dreissena*, but the unquestionable inequivalve character of *Myalina*, in connection with its peculiar striated cartilage area, and the fact that these shells are always found associated with marine types, are sufficient evidences that they have no very close affinities to *Dreissena*.

From an attentive study of the various fossil and recent groups apparently falling within the *Aviculidæ* or more properly *Pteriidæ*,[4] the writer has, in the manuscript work on the Paleontology of the Upper Missouri country, to be published jointly with Dr. Hayden, proposed the following diagnoses of the family *Pteriidæ*, and the subordinate groups into which it seems to be divisible:—

Family PTERIIDÆ (or *Aviculidæ*).

Shell inequivalve, inequilateral, composed of an inner laminated pearly layer, and an outer prismatic substance; left or upper valve always more convex than the other. Anterior margin of the right valve generally more or less sinuous for the passage of the byssus. Cartilage submarginal, simple, and placed in a single cavity or depression near the beaks, or divided and distributed in a series of furrows crossing the cardinal facet at right angles,—or, in some of the older fossil genera, occupying linear furrows in the cardinal area or facet, ranging more or less nearly parallel to the hinge line. Hinge with or without teeth. Scar of adductor muscle large and usually subcentral; anterior muscular impression generally small and placed near the beak. Pallial line simple, often irregularly dotted.

[4] Since *Scopoli's* name, *Pteria*, was regularly established in 1779; while Klein's name, *Avicula*, was not affirmed by any author understanding or recognizing the Linnæan ideas of genera and species, until Bruguiere adopted it in 1789. I think Dr. Gray is right in restoring Scopoli's name, *Pteria*, for this genus.

The animal in the existing typical genus has the mantle-margins freely open and doubly fringed; foot small, grooved, and having the power of spinning a byssus; palpi large; gills two on each side, crescent shaped, free or connected with each other posteriorly, and to the mantle.

The foregoing diagnosis of the shells of this family is framed so as to include species belonging to three subordinate groups, the first of which, so far as known to the writer, has no living representatives, and seems to have been mainly confined to the Paleozoic epoch. The other two groups (the *Pteriinæ* or *Aviculinæ* and *Melininæ*) are both represented by living species in our existing seas. These three sections or subfamilies may be characterized as follows:—

1. Pteriniinæ, (or *Pterinia* group).

Cartilage apparently occupying a series of linear furrows, ranging more or less nearly parallel to the cardinal margin, in a usually broad, flattened cardinal facet or area. Anterior muscular scar sometimes moderately developed, and deep.

Includes *Pterinia*, *Myalina*, *Ambonychia*, and probably *Actinodesma*, *Gryphorhynchus*, and several undefined Paleozoic groups. A part of the species referred to the genus *Megambonia*[6] will probably be found to belong to some genus of this group, if not indeed to the genus *Pterinia*, though the typical species appear to belong to the *Arcidæ*.

2. Pteriinæ, (or *Aviculinæ*).

Cartilage mainly or entirely confined to a single, more or less defined, depression or cavity behind the beaks. Anterior muscular impression very small.

Includes *Pteroperna*, *Pteria* (or *Avicula*), *Margaritifera*, *Malleus*, *Aucella* and *Eumicrotis*. The following extinct genera also probably belong here, viz:—*Monotis*, *Halobia*, *Pteronites* and *Posidonomya*, with apparently some undescribed fossil genera.

3. Melininæ, (*Perna* or *Isognomon* group.)

Cartilage divided and distributed along the hinge in a series of furrows crossing the cardinal area at right angles to the hinge line. Anterior muscular scar generally very small.

Includes *Crenatula*, *Melina* (=*Perna* Brug., not Adanson), *Bakevellia*, *Gervillia*, *Inoceramus* and *Pulvinites*.

The first two of these sections seem to be more nearly related to each other than either is to the third; and it is not improbable that they will be found connected by a few Triassic and Jurassic species presenting intermediate characters, when the hinge and interior of a greater number of fossil species are known. The Jurassic genus *Pteroperna*, for instance, has hinge teeth analogous to those of *Pterinia*, with apparently a cavity or depression for a cartilage similar to that of *Avicula*. Such exceptional cases, however, cannot be urged as a reason for not recog-

[6] *Megambonia aviculoides*, and *M. lamellosa* Hall, for instance.

nizing the convenience of sections or intermediate groups between families and genera, for it is highly probable that if we knew all the characters of all the species that ever existed, from the beginning of animal life to the present epoch, we should find all our groups blending imperceptibly together, or at least far from being so sharply defined as they appear in works on natural history.

The Pterinia group, or subfamily, probably includes most of the Paleozoic species usually referred to *Avicula*, especially those from the Silurian and Devonian rocks. Indeed, I very much doubt the existence, during the deposition of the Paleozoic rocks, of true *Aviculas*, as that genus is known to conchologists, and typified by the existing *A. Hirundo*. At any rate, I have never seen a specimen, nor can I remember a figure, of any species showing the hinge of a true *Avicula*, from any of our American Paleozoic rocks. So far as my knowledge extends, all the Silurian and Devonian species, the hinge in which has been seen, want the cartilage cavity of the modern *Aviculas*, and have the striated hinge facet, or the oblique hinge teeth, (one or the other or both) of *Pterinia*, more or less distinctly marked. In addition to this, most of the Silurian and Devonian, and many of the Carboniferous species, the hinge in which is unknown, present more the external appearance of the European species figured by Goldfuss and others, in which the internal characters of *Pterinia* are known to exist.

Prof. McCoy, some time since, referred three of our American Paleozoic species,—*A. demissa*, *A. pleuroptera*, and *A. subfalcata*, to *Pterinia*;—and the figures of *A. securiformis* Hall show the broad striated cardinal facet of that genus. I have also ascertained, from the examination of a very fine natural cast of the interior of *Avicula Flabella* Conrad, from the Hamilton Group, of Cayuga Co., N. Y., that it presents all the characters of a true typical *Pterinia*. The specimen examined is a cast of a left valve, showing the impression of three rather long oblique hinge teeth behind the beak, and of seven or eight shorter ones in front,—together with the cast of a deep, rather large, anterior muscular impression. The Chemung *A. acanthoptera* Hall, and *A. spinigera* Conrad, present much the general aspect of true *Aviculas;* but Prof. Winchell describes, from the Michigan rocks, a form which he refers to the first of these species, as having "a long posterior cartilage facet."

From all that is now known in relation to the affinities of these shells, we may safely infer that probably all of our Silurian and Devonian species, especially those of the Hamilton and Chemung groups, usually referred to *Avicula*, will be found to possess the internal characters of *Pterinia*, or of undescribed genera.

It is an interesting fact that the ancient *Pterinias* seem to bear the same relations to the existing *Aviculas*, or *Pterias*, that the

old *Aviculopectens* do to our modern *Pectens*.[8] For, in the modern types of the *Pectenidæ* and *Aviculidæ*, the cartilage is mainly or entirely confined to a pit or depression under or near the beaks, while, as already explained, in the Paleozoic *Pterinias* and *Aviculopectens*, we observe no such pit or depression, the cartilage being apparently attached by a series of linear furrows in a more or less wide, flattened, cardinal area, much as in the *Arcidæ*. This similarity in the arrangement of the cartilage of *Aviculopecten*, to what we see in *Pterinia*, *Myalina*, and some of the other groups here placed as a section of the family *Pteriidæ* (=*Aviculidæ*), together with the somewhat produced posterior ear of some of the *Aviculopectens*, would have led the writer to concur with Prof. McCoy, Mr. Woodward and others, in referring that genus also to the *Aviculidæ*, had it not been for the fact, that, on subjecting sections of a typical Carboniferous species (*Aviculopecten amplus* Meek & Worthen) to a microscopical examination, it was found not to possess the prismatic structure of the *Aviculidæ*, but the peculiar corrugated tabular structure of the *Pectenidæ*. From this fact, as well as the less oblique and more *Pectenoid* form of the *Aviculopectens*, we can scarcely doubt the propriety of including them, with probably several undescribed Paleozoic genera, as a section or subfamily of the *Pectenidæ*, parallel to the ancient *Pterinia* group in the *Aviculidæ*.

Amongst the genera here included provisionally in the group *Pteriniinæ*, the new name *Gryphorhynchus* will be observed. This is proposed for the reception of a group of small *Triassic* shells, of which *Avicula gryphæata* of Munster is the type, (see *Goldf. Petref. Germ.*, ii, p. 127, pl. cxvi, fig. 10, *a*, *b*, *c*, *d*, *e*, *f*, *g*). This genus may be briefly characterized as follows:—

Genus GRYPHORHYNCHUS, *Meek*.—Shell small, thick, nearly or quite as wide as long, very slightly oblique, plano-convex, or sub-hemispherical, the right valve being flat or concave, and the left very gibbous; posterior and anterior margins, somewhat sinuous, but neither valve with a defined byssal sinus. Beaks sub-central; that of the left valve elevated, gibbous, strongly incurved, and at the extremity directed obliquely forward; beak of right valve truncated so as not to be distinct from the cardinal margin. Hinge line equalling the greatest length of the shell, ranging more or less nearly at right angles to the umbonal axis; in both valves provided with a wide, well defined cardinal area. Ears subequal, not produced, concave in the right valve, and convex in the left, in which latter the anterior one is separated from the swell of the umbo by a deep oblique sulcus. Surface with fine, sometimes decussating striæ. Hinge with several small irregular teeth near the middle.

[8] The same relations are also observed between nearly or quite all of the Paleozoic *Nuculas*, so-called, and the true *Nuculas* of our modern seas.

This genus includes *G. gryphæatus* and *G. tenuistriatus* (=*Avicula gryphæata* and *A. tenuistriata*, of Munster, *Goldf. Petref. Germ.*, ii, 127–8).

In the same group may also be placed, as the type of a distinct subgenus, another little Triassic species described by Munster as *Avicula decussata* (*Goldf. Petref. Germ.* ii, 128, cxvi, 12 *a*, *b*). For this form I would propose the subgeneric name *Actinophorus*. It agrees with the typical species in all essential characters, excepting in being much more oblique, in having its posterior margin truncated at right angles to the hinge, instead of being slightly sinuous; and particularly in having the left valve ornamented with strongly elevated, distant, radiating costæ or plications.

I have not been able to see the prismatic structure in either of these types, but, from all analogy, I should suppose it could be detected in specimens in a better state of preservation. So far as known to the writer, this genus has not been discovered in America, and has only been found in the St. Cassian deposits of the Tyrol.

Under the *Aviculinæ* or *Pteriinæ*, it will also be observed that a new generic name, *Eumicrotis*, has been introduced. This is proposed for a well known type sometimes referred to *Avicula*, sometimes to *Pecten*, sometimes to *Monotis*, and by others to *Aucella*. Its type is *Monotis Hawni* Meek & Hayden, from the Permian rocks of Kansas. It also includes the closely allied European *Eumicrotis speluncaria*, (= *Gryphites speluncaria*, of Schlotheim, = *Monotis speluncaria* of King and others); also *E. radialis* (= *Pecten radialis* Phillips); and *E. Garforthensis*, (=*Monotis Garforthensis* King). This genus may be described as follows:—

Genus EUMICROTIS, *Meek*.—Shell more or less orbicular, planoconvex, the left valve being usually very convex, and the right flat or a little concave; not distinctly auriculate, the ears being nearly obsolete. Beaks subcentral, very slightly oblique, unequal, that of the left valve often elevated, gibbous and incurved; the other very small, and scarcely projecting above the hinge line. Hinge short, narrow edentulous. Byssal notch, or sinus of right valve, narrow, deep, sharply defined and separated from the hinge line by a small rudimentary ear, which does not project beyond the anterior margin of the valve. Scar of adductor muscle large and subcentral, those of the retractors small and placed near the beaks. Surface generally with radiating, vaulted, scaly costæ, much more strongly marked on the left than on the right valve.

The species of this genus have been usually referred to Bronn's genus *Monotis*. A careful comparison, however, of our Kansas specimens of the species described by the author in con-

nection with Dr. Hayden, under the name *Monotis Hawni*, with authentic European specimens of the type of Bronn's genus, (*Monotis salinarius*) now in the collection of the Smithsonian Institution, has satisfied me that they ought not to be placed in the same genus. In the first place, the type of *Monotis* is an obliquely oval, compressed, very nearly equivalve shell, with depressed, subequal beaks, presenting altogether a marked contrast with the general physiognomy of the shells belonging to the Permian and Carboniferous group under consideration. The most important difference, however, is the total absence of any traces of a byssal sinus in the anterior margin of either valve of the typical *Monotis*, the anterior margins of both valves being smooth, rounded, and without even the most obscure indication of an emargination, to represent the deep, sharply defined, byssal sinus of *Eumicrotis*.

I know nothing of the hinge, or of the microscopical structure, of *Monotis salinarius*, the specimens at the Smithsonian Institution being firmly imbedded in the very hard brittle matrix, and not in a condition to show any traces of minute structure. Dr. Carpenter, however, has examined a species—*Avicula cygnipes*, of Phillips—(which is unknown to the writer), supposed to be congeneric with the type of Bronn's genus, and finds it to possess the structure of the *Pectenidæ*, rather than that of the *Aviculidæ*. On examining thin sections of our Kansas shell, the type of the genus here described, by the aid of a magnifying power of about three hundred and fifty diameters, the prismatic structure of the *Aviculidæ* is distinctly visible.

Prof. McCoy was evidently much nearer right when he referred the European species of this group to Count Keyserling's Jurassic genus *Aucella*, than those who identified them with Bronn's genus *Monotis*. *Aucella*, however, although more nearly allied, was founded upon a distinct group of oblique, gibbous shells, all of which are destitute of radiating costæ or striæ, but ornamented with concentric undulations, giving them much the general appearance of some species of *Inoceramus*. They also have a small peculiar concave ear just in front of the beak of the left as well as of the right valve, formed by the inflection of the margin of the valve, unlike anything we see in the left valve of *Eumicrotis*. Count Keyserling's figures and description also show that the scar of the adductor muscle is placed much nearer the ventral margin in *Aucella* than in *Eumicrotis*. *Aucella* would therefore seem to bear similar relations to *Eumicrotis*, that *Posidonomya* does to *Monotis* proper, as typified by *M. salinarius*.

It is remarkable that, even in late European publications, we see the so-called *Monotis speluncaria* placed in the genus *Avicula*.

There is still another small group of Jurassic shells represented by one species in our collection from the far West, for which I

had thought a subgeneric name should be proposed. Farther comparisons, however, with specimens of some European species of this type, have led to the conclusion that these little shells form a section of the genus *Eumicrotis*, probably too closely connected by some intermediate forms to merit a distinct subgeneric name. The western species of this section alluded to above is *Avicula? curta* Hall, (*custa*, typ. err., *Stansbury's Report*, Expl. Great Salt Lake, 412, pl. ii, fig. 1, *a*, *b*.)[1] This section also includes the very closely allied European species *Monotis substriata* Munster: also *M. decussata*, and *M. Alberti* Munster, (*Goldf. Petref. Germ.*, ii, p. 138–9,) as well as a species figured by Goldfuss as *Monotis echinati*, (id., pl. cxxi, 6.)

These shells have much the general outline of the typical species of *Eumicrotis*, being short or suborbicular and but very slightly oblique, without any anterior ear, and generally having the posterior ear much abbreviated. They differ, however, in being smaller as well as more nearly equivalve shells, and in having the beak of the left valve much less prominent. Their valves are also destitute of an oblique sulcus often seen extending down the posterior side of the typical forms of *Eumicrotis*, and have a more regular appearance. They have generally a merely striated surface, and a very sharply defined byssal sinus near the beak of the right valve; in some of the species, however, the left valve has small radiating scaly ribs.

The structure of *E.* (*Avicula*) *curta* Hall sp., as seen by transmitted light under a high magnifying power, is finely prismatic.

In conclusion, I would remark that the numerous widely different types from the older rocks, figured in the various works on Paleontology under the names *Avicula*, *Pecten*, &c., show that much has yet to be done in classifying these shells, and that it will be necessary to establish a number of new genera for their proper distribution. I would also call the attention of paleontologists to the valuable assistance to be derived, at least in many cases, from microscopical examinations, in determining the family affinities of the ancient fossil genera of *Aviculidæ*, *Arcidæ* and *Pectenidæ*; especially, where the condition of the specimens under investigation is such as to prevent the nature of the hinge and interior from being determined. How far, however, the different types of structure may have been constant, amongst all the ancient genera of these families, remains to be determined by the examination of a larger number of species.

[1] The figures here referred to are not recognizable, but we know our shell to be the same, from comparing our specimens with the type of that species, collected at the same locality.

ART. XXI.—*On some Minerals of the Chlorite Group;* by JOHN B. PEARSE.

THE diversities of color among the varieties of the mineral species are in many cases still unexplained. A case of this kind occurs in the so-called kämmererite, from Lancaster county, Pa., of which there are three kinds—one colored pure green, a second red and green, while the third is of a pure red. The following investigation was undertaken to determine, if possible, the cause of this variation; and as the results have proved interesting, they have been further discussed in their general relations.

The mineral is in distinct crystals. There is the strongest evidence that all belong to the trimetric system, closely resembling many specimens of chlorite and some crystals of clinochlore. They are usually hexagonal in form, rising from their base as a truncated pyramid, but the lateral surfaces are so striated as to be incapable of measurement. The pyramid is made up of a pile of crystalline plates, with their slightly projecting edges manifestly replaced, indicating a dome and an octahedron.

The three varieties are well defined, the color of the first being a pure green, sometimes a rich emerald-green, while that of the second varies considerably between these two tints, being sometimes of a pure white; and that of the third is red, with an occasional tinge of reddish-white. In the second, the colors are confined to the laminæ, instead of mixing and giving a medium tinge. The third was also dichroic in the direction of the planes of its axes, being red in the direction of its shorter lateral axis, but of a violet-blue or hyacinth in that of the longer axis.

The hardness of the green and red is 2·75; the specific gravity of the green at 64° Fahr. 2·355, that of the red 2·383, which is perhaps a little too low, as it was impossible to free the crystals of a few minute bubbles of air. They consist of flexible micaceous plates, with a vitreous lustre, and white streak. Their blowpipe reactions show the presence of chrome, and silica, the absence of manganese in both, and the absence of fluorine in the green. Traces of the alkalies were shown in the red. Both the green and red are soluble in sulphuric acid with separation of silica, but are not acted on by chlorhydric acid. The purplish green not being obtained in sufficient quantity is not included in this description. This deficiency however proved unimportant, as the analysis showed its identity with the red.

Extreme care was taken in selecting the material for analysis. Fresh and perfect crystals were used for each analysis of the same variety, in order to certify undeniably the composition.

In no case was any crystal chosen the color of which was indistinct.

The following is an outline of the method of analysis adopted. After solution by means of carbonate of soda, and chlorhydric acid, the usual precautions being taken for an accurate estimation of the silica, the filtrate was rendered slightly alkaline with ammonia which precipitated the sequioxyds of iron, chrome and aluminum, with part of the nickel. This precipitate being dissolved was treated with acetate of soda, which separated the nickel oxyd from the sesquioxyds; the latter was then dried, weighed, pulverized carefully with carbonate of soda, and then fused together with nitrate of potash for chrome. This metal was estimated with the precautions detailed by Genth.[1] The residue being again dissolved, the iron was separated from the aluminum by caustic potash with the addition of sulphid of potassium. Great care was taken that the sesquioxyds of iron and aluminum were free from silica and perfectly washed. The nickel remaining in solution after the acetate separation was precipitated by sulphid of potassium. The filtrate from the ammonia precipitation, after the destruction of the ammonia by nitric acid, was treated by sulphid of potassium, as above, to separate the nickel from the lime and magnesia. The lime was precipitated as oxalate, and estimated as sulphate; the magnesia in the usual way. After the solution of the sulphid and the estimation of the oxyd of nickel, the oxyd was redissolved, and separated by ammonia from the impurities which cling to nickel so closely. The analyses, so described in outline, gave the following results—two determinations being generally made of each constituent of the green and reddish-green.

	Green.			Reddish-green.			Red.
	No. 1.	No. 2.	Average.	No. 1.	No. 2.	Average.	
SiO_2*	28·800	28·444	28·622	31·515	32·200	31·857	31·315
Al_4O_3	18·375	....	18·375	13·746	....	13·746	12·840
Cr_4O_3	1·935	2·000	1·967	2·154	....	2·154	2·985
Fe_2O	3·862	3·606	3·734	2·307	....	2·307	2·457
Ni_2O	·370	....	·370	·231	·200	·215	·450
Ca_2O	1·590	1·303	1·446	1·273	....	1·273	·815
Mg_2O	31·766	32·483	32·125	34·871	34·929	34·901	35·020
H_2O	13·900	14·135	14·025	13·933	14·033	13·983	13·200
			100·664			100·436	99·082

* Si = 28·4, O = 16.

The joint weight of sesquioxyds in the green was 25·68 and 24·89; that of their separate determinations 24·32, the latter confirming the former, after exclusion of silica. These analyses show that the red and reddish-green are identical, but that they differ from the green. Since there is one per cent more of oxyd

[1] Chem. News, vol. vi, p. 32.

of chrome, and one and a third per cent less of protoxyd of iron in the red than in the green, the first question as to the cause of the difference of color is unanswered by analysis. It is possibly due to molecular arrangement.

The following formulæ exhibit the number of each class of ingredients, the sesquioxyds of chrome, iron, and aluminum being represented by Al_4O_3 and the protoxyds of magnesium, calcium, iron, and nickel, by Mg_2O, because aluminum and magnesium constitute by far the larger proportion of the bases.

Green, $5SiO_2+2Al_4O_3+9Mg_2O+8H_2O$.

Red, &c., $7SiO_2+2Al_4O_3+13Mg_2O+10H_2O$.

Without attempting at present to reconcile these numbers to any theory of the silicates, it will prove interesting to discuss the reliable results of analysis attained by different chemists, with different specimens of this and other minerals referable to the chlorite group. In order to show their mutual relations more clearly, I subjoin a table of their atomic composition, reducing them all to the proportions arising from two atoms of alumina.

Proportion of atoms in chloritic minerals.

	SiO_2	Al_4O_3	Mg_2O	H_2O	Analyst.
1. Kämmererite, crystallized,	5	2	8	8	Hermann.
2. My green, "	5	2	9	8	Pearse.
3. Chlorite (average analysis)	6	2	10	8	Rammelsberg.
4. Kämmererite, fibrous,	6	2	10	8	Hermann.
5. Chonikrite, massive,	7	2	10	6	von Kobell.
6. Rhodophyllite, crystallized,	7	2	12	10	Genth.
7. My red, "	7	2	13	10	Pearse.
8. Kämmererite, "	8	2	14	10	Smith & Brush.
9. Pyrosclerite,	8	2	12	10	von Kobell.
10. Tabergite,	9	2	14	10	Svanberg.
11. Kämmererite, crystalline,	9	2	11	10	Hartwall, Garrett.
12. Pyrosclerite, impure,	9	2	14	6	Lychnell.

A study of the above series of minerals by formulæ, and by their general agreement in external characters, establishes their relations and connection. I might have extended the list to embrace epichlorite, metachlorite, ripidolite, delessite, etc., but the above are sufficient for the discussion.

Genth's analysis of rhodophyllite (6) gives nine or ten atoms of water, and twelve atoms of magnesia; my red, and reddish-green (7) give ten atoms of water and rather less than thirteen atoms magnesia. I therefore prefer the formula I have given for Genth's rhodophyllite, with which my red is identical. Smith & Brush's kämmererite differs from rhodophyllite by an atom of olivine. These two formulæ may be regarded as reliable, being derived from well executed analyses of crystallized specimens.

We may reject at once from the above list chonikrite (5), and pyrosclerite (12) as impure. The kämmererite of Hartwall and Garrett (11) not being quite pure, and differing but slightly from von Kobell's pyrosclerite (9) might be referred to the latter, as Dana has done. But as pyrosclerite (9) differs by only one atom of silica from rhodophyllite, the latter in crystals, and the former of doubtful purity, pyrosclerite may be regarded as a less pure rhodophyllite. Svanberg's tabergite differs from Smith and Brush's kämmererite by only an atom of silica, and because the latter was in crystals, it is the true mineral, and the former an impure exhibition of it. I therefore refer the formulæ of 9, 10, and 11, to 6, 7 and 8, or 6 and 8.

It is noticeable that Hermann's kämmererite (4) is identical with chlorite, as determined by Rammelsberg's discussion of the latter's composition, but the former being fibrous, its purity may be doubted, and its formula set aside. The formula of chlorite is accepted as correct.

Comparing my green crystals (2) with Hermann's kämmererite (1) it is seen that they are manifestly identical; but as mine were carefully selected, perfect, transparent crystals, I give the preference to my own formula. Comparing my green with chlorite, it is clearly distinct; and I have therefore named it *Grastite*, (Greek γράσις, *grass*), from its green color.[2]

Our critical examination of the above series of minerals limits their number to four, viz. Nos. 2, 3, 6, (7) and 8, which are here presented as distinct varieties, together with the formulæ of olivine, augite, and serpentine, for the sake of further discussion.

Nos.	SiO_2	Al_4O_3	Mg_2O	H_2O	
2. Grastite,	5	2	9	8	Pearse and Hermann.
3. Chlorite,	6	2	10	8	Many analysts.
6. Rhodophyllite,	7	2	12	10	Genth and Pearse.
8. Kämmererite,	8	2	14	10	Smith & Brush.
Augite,	1		1		
Olivine,	1		2		
Serpentine,	2		3	2	

A comparative study of the above shows the following remarkable differences between these varieties of the chlorite group:

Grastite + augite = chlorite.
Grastite + serpentine = rhodophyllite.
Grastite + olivine + serpentine = kämmererite.

In other words, the differences of composition between members of the chlorite group are the simpler minerals associated with them in locality, or from which they have been heretofore assumed to be derived.

[2] My apology for a new name is that not one of those heretofore proposed for any member of this group is applicable.

If I may be allowed to hazard a conjecture as to the introduction of alumina to those simple minerals to build up the chlorite group, I suggest that it is due to the conjoined influence of adjacent decomposed feldspar, and a solution of magnesia. For decomposed feldspar, I take the most general composition of kaolin, and for solution of magnesia, brucite. Grastite and kämmererite may be supposed to be formed thus:

	SiO_2	Al_4O_3	Mg_2O	H_2O
Grastite:				
1 atom of kaolin,	3	2		3
2 " " olivine,	2		4	
5 " " brucite,			5	5
1 " " grastite,	5	2	9	8
Kämmererite:				
1 atom of kaolin,	3	2		3
3 " " olivine,	3		6	*
1 " " serpentine,	2		4	2
5 " " brucite,			5	5
1 " " kämmererite,	8	2	14	10

A moment's consideration will show that these conjectures are not unfounded. Chlorite is found where talcose matter and feldspar are associated or near together, and is supposed to arise from augite. The others are found in or near serpentine with adjacent feldspar, and serpentine has been supposed to be derived from olivine. The locality in which grastite, rhodophyllite, and kämmererite are remarkably developed, viz. Lancaster county, Penn., abounds in brucite. In fact brucite either as such or altered into serpentine, is a common constituent of serpentine rock. Thus the marmolite of Hoboken, and of other localities, a pure serpentine, exhibits all the crystalline peculiarities of brucite. A similarly altered brucite from Siberia, in the collection of J. A. Clay, Esq, of Philadelphia, has the precise hexagonal forms of the fine crystals of brucite from Lancaster Co., Penn. We have therefore only hazarded a natural conclusion, that chloritic minerals are formed from their simpler mineral associates.

Philadelphia, Oct. 26th, 1863.

ART. XXII.—*Notice of a small collection of Fossils from the Potsdam Sandstone of Wisconsin and the Lake Superior Sandstone of Michigan;* by Prof. ALEXANDER WINCHELL.

THE University of Michigan is in possession of a small collection of fossils from the Potsdam Sandstone of Sauk county, Wisconsin, contributed by one of the *alumni*, Joseph W. Wood. The interest which attaches to every vestige of organic life belonging to this age induces me to offer a few words in reference to the new data in my possession.[1]

Mr. Wood, in transmitting the specimens, writes: * * * "They are found overlying, and in connection with, the "quartzite" of the Devil Lake[2] and Baraboo Bluffs. * * * The quartzite is an indurated sandstone containing ripple marks in abundance—also conglomerates, and, in places, thin layers of talcose slate. It has been upheaved along an east and west axis, * * * the main ridge pushing the Wisconsin river to the east, where it almost forms a junction with the Fox, and at which point the two are joined by a canal. There are many minor ridges, running both parallel and crosswise." About three miles south of the village of Baraboo, the main ridge has been broken open, forming an *anticlinal* valley, in which rests Devil Lake—the semi-stratified quartzite dipping rapidly toward the north-northeast on the east side, and rapidly toward the northwest on the west side, and forming bluffs 450 and 500 feet high on the two sides respectively. The longer axis of the lake is transverse to the main axis of the ridge. South of the bluff, on the east side, and beginning opposite the southern portion of the lake, is a low, level valley, which extends eastward to the Wisconsin river. South of the valley, and bounding the lake at its southern extremity, is a low bluff presenting nearly horizontal stratification; but probably dipping gently southward, since, in the region three or four miles farther south, it supports the first outliers of the Calciferous sandrock.

The high bluffs surrounding the lake are described by Mr. Wood (and also by Prof. Hall in the Wisconsin Report) as consisting entirely of bluish or iron-stained quartzite, exhibiting a

[1] The present paper was written and accepted for publication in this Journal before I had become aware of the existence of the very important paper recently issued by Prof. Hall on the Potsdam sandstone of the Northwest. Of the patience and research whose results are set forth in this exhaustive monograph, I here express my great admiration. It will nevertheless be observed that Prof. Hall's monograph does not embrace a notice of any fossils found as far south as those which form the subject of this paper; and I feel that some interest must still attach to the descriptions which are here presented. It will appear evident that a few features have been added to the present paper since the appearance of Prof. Hall's monograph. Other recent information from Mr. Wood has also been incorporated.

[2] Sometimes improperly styled "Spirit Lake."

gradual passage into an overlying conglomerate, which, in turn, assumes, above, the characteristics of the Potsdam sandstone. Both insist on the absolute continuity and conformability of the quartzite, conglomerate and sandstone. Mr. Wood says: "It is in the northern slope of the main ridge (on the east of the lake) that I found these fossils. If the sandstone containing them shall be called 'Potsdam,' and the main ridge 'Quartzite,' then I should say that they were a continuous deposit; and I do not know of any reason for separating them, only that they differ in hardness; while it is only at the extremes of the scale that this difference is manifest." Prof. Hall states (*Geol. Rep. Wis.* 1862, pp. 11 and 12) that the quartzite is terminated upward by a conglomerate which graduates into the Potsdam sandstone; and agrees with Mr. Wood, that "in some cases the passage from the conglomerate to the sandstone is so gradual that it is impossible to point out a line of demarcation. In the lower part," Prof. Hall further says, "the conglomerate is so destitute of any other materials than the sand and pebbles of the quartzite below, that it bears little affinity to the sandstone above." Nevertheless, Prof. Hall is of the opinion that "the quartzite holds the same relative position to the Potsdam sandstone as the Huronian system of the Canada survey."

Some of the fossiliferous fragments forwarded by Mr. Wood contain pebbles three-fourths of an inch in diameter; and I should infer from this circumstance, as well as the position of the fossils upon the northeastern flanks of the bluffs, that the remains under consideration occupied a place near the boundary line between the conglomerate and the recognized Potsdam sandstone.

I insist particularly upon the stratigraphical position of these fossils, because they show, contrary to the conclusions of Prof. Hall's monograph, that *Dicellocephalus* and *Ptychaspis* occur at the recognized base of the Potsdam sandstone, as well as above. The alternative of this conclusion is an admission that *the conglomerate and quartzite are truly* (*as they appear to be*) *the downward continuation of the Potsdam sandstone*, and the prolongation of beds which, further north, exhibit a more typical character. If, as I infer from Mr. Wood's communications, the mass of quartzite is superimposed, a little farther south, by the outliers of the Calciferous sandrock, this fact would give countenance to the alternative suggested.

Scolithus linearis.

S. linearis Hall, is present in abundance in some of the fragments, in the form of straight, cylindrical, nest-like cavities, two or three inches long, extending vertically to the planes of bedding. They vary from ·05 to ·27 of an inch in diameter.

ORTHIS BARABUENSIS, n. sp.

There are several imperfect specimens of an *Orthis*, apparently of the type of *O. biforatus*. The form is transverse, with a straight hinge-line, and the sub-equal beaks a little elevated above it. Greatest width of shell along the hinge, in front of which the sides are considerably constricted, and continue to approach each other, though less rapidly, to the somewhat straight anterior margin. Ventral valve with a sinus of moderate depth, which is rather broad, and near flat at bottom. Surface with sixteen or eighteen ribs visible on the cast, the strongest of which limit the mesial sinus, which has in the middle a barely visible costal ridge. The interior of this valve exhibits a pair of rudimentary hinge teeth, separated by a triangular foramen. The interior myary scars occupy only a small space near the beak, and present an elliptical outline. The dorsal valve is equally convex with the ventral, and exhibits a broad, depressed mesial fold.

Length of hinge-line ·76 (100); length of shell from beak to anterior margin ·38 (50).

Dr. D. D. Owen (*Rep. Wis. Io. and Min.*, p. 575) and Shumard (*St. Louis Trans.*, i, 627) have made allusion to the existence of this genus in the Potsdam sandstone of the northwest; and a species has just been described by Prof. Hall under the name of *O. Pepina*. Our specimens from Baraboo differ from both this and *O. Coloradoënsis* Shum., in its more transverse shape, fewer ribs and want of concentric lines.

STRAPAROLLUS (OPHILETA) PRIMORDIALIS, n. sp.

A planorboid shell, three-fourths of an inch in diameter, and having the apex of the spire depressed below the level of the outer whorl. The number of whorls is probably about five, but only the last two are preserved in the best specimens. The tube enlarges very gradually, and is marked by a distinct carina just above the peripheral line, above and below which is a shallow groove.

Some of the specimens of this fossil greatly resemble the figure of *Ophileta complanata* Vanuxem, from the Calciferous sandrock of New York; but the volutions enlarge a little more rapidly, and present a distinguishing angulation. No allied species has been described from the Potsdam sandstone (unless it be *O. compacta* Billings, a description of which I have not seen). The *Euomphalus? vaticinus* Hall (16*th Rep. N. Y. Regents*, p. 136) is described and figured as "gently convex above."

PLEUROTOMARIA? ADVENA, n. sp.

A trochoid or sub-turreted shell, of at least four whorls, which are depressed-convex externally, and apparently destitute

of all superficial ornaments. But three whorls have been seen; these are ·66 inch in height, and the lower one is about ·77 inch in diameter—the three being of nearly equal height.

This fossil is quite unlike anything described from the Potsdam sandstone; and there is nothing in the Calciferous sandrock which approaches nearer than *Holopea Proserpina* Billings (Pamphlet, Jan. 1862, p. 28), with which this may be congeneric.

DICELLOCEPHALUS MINNESOTENSIS, Owen.

Several specimens occur in the collection which I feel obliged to refer to this species. Some well preserved pygidia do not disagree with Owen's and Hall's (*Foster and Whitney's Rep. on L. Sup. Land Dist.*, pl. xxiii, fig. 30) figures, except that Hall's specimen had lost its caudal flap—a feature well preserved in my specimens, and distinctly reflected upward. Nevertheless, no caudal spines are preserved in any case; and the condition of the specimens would indicate that they were wanting. An imperfect cephalic shield presents a flat border, about as wide as the caudal flap, and, like it, turned slightly upward, and is destitute of a thickened margin. The glabella is truncately rounded in front; the two sides are nearly straight, but not perfectly parallel—being approximated anteriorly at an angle of about 12°. There is at least one furrow extending across the glabella; and in front of this, opposite the anterior extremity of the palpebral lobes, another furrow on each side, reaching less than one-third the distance transversely across the glabella. The course of the great suture in its anterior extension conforms to the requirements of this species.

A doubt may exist whether these specimens are correctly referred, in consequence of the absence of the caudal spines and the defective condition of the posterior portion of the cephalic shield. It seems to me, however, that a pair of blunt spines, in an attenuated peripheral part like the caudal flap, cannot form an indispensable diagnostic character. The direction of the facial suture is exactly that of *D. Minnesotensis;* and the inclination of the sides of the glabella, even if slightly greater than is usual for this species, is not as great as in *D. misa* Hall. The pygidium conforms, in its want of spines, to that of *D. misa*, but the configuration of the glabella and the anterior lobe of the fixed cheek deviate decisively from that species.

DICELLOCEPHALUS PEPINENSIS, Owen.

An imperfect cephalic shield shows a narrow border, with a decidedly thickened margin, which is broader than the furrow between it and the front of the glabella. The glabella is prominent, with sub-parallel sides and an obtusely rounded anterior extremity. Opposite the middle of the prominent palpebral

lobes, a furrow passes quite across the glabella, being curved backward in the middle. Behind this is another nearly parallel furrow, and in front is a pair of faint furrows situated nearly opposite the anterior extremity of the palpebral lobe, and each traceable about one-third the distance across the glabella. Another glabella, very similar to this, shows three transverse furrows, besides the anterior interrupted furrow.

A finely preserved pygidium presents a strong convexity, especially in the middle lobe. Aside from the marginal flap, the external outline is nearly semicircular, with the anterior margin considerably curved. The lateral lobes are strongly convex, becoming less so nearer the border, and abruptly joining the caudal flap, at an inclination of about 45°. The pleuræ are furrowed in such a manner that there seems to be an accessory pleura between each two principal ones. The articulations are seven in number in both the axial and side lobes, and extend nearly to the terminal apex of the middle lobe. The caudal flap is flat, and about as wide as the middle lobe at its anterior end, and marked uniformly through its whole length by eight or more rigid concentric striæ. No indications of caudal spines.

This pygidium was originally referred to this species on such information as was accessible, amongst which was Hall's figure in the Wisconsin Report (p. 22, fig. 4), showing indications of a similar striated caudal flap. I am not able by the help of Prof. Hall's last memoir to change the reference, although I perceive the pygidium does not fully agree with the complete characters now published. I am inclined to think this pygidium has not previously been described.

PTYCHASPIS BARABUENSIS, n. sp.

The collection embraces some fragments of the cephalic and caudal shields of a large trilobite, which, while its generic relations are somewhat indeterminate, has a certain expression which is peculiar. The head is about 2·4 inches broad, and rather convex; the thickened and convex margin of the border is separated from the glabella by a narrow, concave furrow, giving the border a width of three-tenths of an inch. Posteriorly, the border is continued in genal points which attain a length not less than three times the length of the glabella. The movable cheek is swollen and separated by a deep transverse furrow from the posterior borders of the cheek. The surface is feebly scrobiculate-wrinkled; though with oblique light it is seen to be distinctly so, and the character is even better shown with a low magnifier, though the cast is preserved in sandstone.

The pygidium which undoubtedly belongs to the same species is 2·9 inches across, and three-fourths of an inch in height. The middle lobe is nine-tenths of an inch across, and is quite

prominent, with its posterior portion inarticulate and broadly rounded. There is no limiting furrow separating it from the lateral lobes; and posteriorly it fades insensibly into the terminal border. The lateral lobes are but faintly articulate, and, meeting behind the axis, form a border three-fourths of an inch broad, which is strongly curved downward on all sides, and presents a circularly curved outline, without any indications of caudal appendages.

The foregoing was written before seeing Prof. Hall's memoir; and I had referred the specimens to *Dicellocephalus*, with a query. I could scarcely doubt of their generic distinctness, but felt reluctant to engage in genus-making without ampler materials. I am happy now to recognize Prof. Hall's new genus as exactly meeting my want. This species differs from *P. Miniscaënsis* Hall, in its broader and fuller movable cheek and broader margin, and much longer genal points.

II. The University has for many years been in possession of some fucoidal remains from the red sandstone of the south shore of Lake Superior. As it is so uncertain when any further paleontological data will be obtained from that region, I do not deem it necessary to defer longer a brief notice of these fossil Algæ.

There are two methods of frond-arrangement noticeable among these remains. One exhibits a rudimentary symmetry, while the other is totally destitute of it. There is little difficulty in deciding that neither form falls under any description that has been published; but it is nearly or quite impossible to determine whether these differences are of generic, specific, or still inferior value. The great variation exhibited in the arrangement of the different portions of the fronds of recent marine algæ, shows how little dependence can be placed upon descriptions founded on detached fragments of these fossil fucoids. Those differences which have been sometimes recognized as marking the bounds between distinct genera, may easily have co-existed upon the same frond. There was great plausibility in the method pursued by the older writers in referring all these remains to the single genus *Fucoïdes*.

There seems, nevertheless, some prospect of utility in making such distinctions as we are able; and while I cannot vouch for the generic characters of the fossils under consideration, I shall refer them provisionally to a Paleozoic genus established by Prof. Hall to receive some fucoids from the Calciferous sandrock of New York.

PALÆOPHYCUS ARTICULATUS, n. sp.

Consisting of large, straight or geniculated, compressed-cylindrical, irregularly articulated, branching stems. The largest

stems are an inch and a quarter in diameter; the transverse section oblong, rounded at the ends, or, in other cases, more nearly a circle. The branches are uniformly much smaller than the main stem, and leave it at an angle of about 30°. One of the most marked peculiarities of the species is the somewhat regular transverse constrictions, which occur at intervals of about half an inch, in most of the specimens. At these constrictions the fucoid has shown a disposition to separate, so that most of the fragments present sharply truncate extremities. Surface smooth.

This fucoid is found abundantly scattered over the surfaces of slabs of dark red, fine-grained sandstone, from the north flank of the Porcupine mountains, Lake Superior.

Collected by Dr. Douglass Houghton, in 1840.

PALÆOPHYCUS INFORMIS, n. sp.

Fucoid apparently consisting of fleshy, leaf-like masses, having an irregularly triangular, elongate, or variously amorphous outline. In some instances it would seem that a hollow, conical piece had been compressed so as to present two opposite edges. Sometimes an irregularly elongate piece presents occasional enlargements and tuberculous eminences. There are some indications that the plant was branched, some of which consist in the close approximation of co-adapted edges without complete junction. The surfaces are smooth and shining. The fragments vary from half an inch to two inches in width.

Abundant in dark red sandstone from Montreal river, Lake Superior—a region where Col. Whittlesey estimates the formation to attain the enormous thickness of 15,000 feet. (*Proc. Bost. Soc. Nat. Hist.*, ix, July, 1863.)

Collected by Dr. Houghton, in 1840.

Similar but thinner and more ill defined fucoids occur in red sandstone three miles west of Eagle river; and again in white sandstone near Carp river, on the south shore of Lake Superior.

In associating these remains with others from the Potsdam sandstone of Wisconsin, I do not intend to express any opinion whether the Lake Superior sandstone is of Mesozoic age, as argued by Jackson and Marcou; or of the age of the Chazy formation, as recently concluded by the Canadian geologists (at least in reference to the St. Mary's sandstone); or the prolongation of the lowest fossiliferous sandstones of Wisconsin, as thought by Messrs. Foster and Whitney, and formerly by Hall, and still earlier intimated in the unpublished notes of Dr. Houghton; or finally, as now intimated by Hall, a formation ranging from a horizon below the fossiliferous sandstones of Wisconsin to the top of the Chazy formation or St. Peter's sandstone.

University of Michigan, Dec. 11th, 1863.

ART. XXIII.—*On the Orbits of Binary Stars;* by Prof. DANIEL KIRKWOOD, Bloomington, Indiana.

THE whole number of double stars hitherto observed is rather more than 6000.[1] The proportion of these in which the duplicity is merely optical cannot now be determined: the number, however, in which a change of relative position had been detected, was, at the middle of the present century no less than 650. In the motions of these bodies, so far as observed, we find one general and striking characteristic; *the orbits are much more elliptical than those of our planetary system.* In Sir John Herschel's Table (1850) of fourteen double stars whose orbits had been calculated, the eccentricity in seven cases is greater than that of Faye's comet (0·5559); while in the case of *Alpha Centauri* it is nearly equal to that of Halley's.[2] We propose to inquire whether this remarkable fact in regard to the sidereal orbits is susceptible of explanation by the nebular hypothesis.

In a former number of this Journal[3] it was stated that the theory of Laplace, which so beautifully accounts for so many otherwise unexplained phenomena of the solar system, might be extended to the binary and multiple systems among the so-called fixed stars. But how, it may be asked, can the same theory explain the almost *circular* orbits of the planets and also the extremely *elliptic* motions of the sidereal systems?

The correllation between the members of a binary system is different from that between the sun and a planet. In the former, both are large, self-luminous bodies; on the other hand, our solar system has resulted from the concentration of the whole mass of a primitive nebula about a single nucleus. Now if a mass of nebulous matter, in which the process of condensation has commenced, have a very slow rotation, and if, instead of a *single* center of attraction, *two* distinct nuclei be formed, the consequence may be its complete separation into two bodies while the rotation is yet so slow that the centrifugal force as compared with the centripetal is too feeble to produce a nearly circular motion. While, therefore, orbits of small eccentricity must characterize planets formed from the abandoned equatorial rings of a condensing nebula, orbits highly elliptical may be regarded as the probable consequence of a separation in the earlier stages of its physical history.

[1] The components being less than 32″ asunder.
[2] The eccentricity of the former is 0·95; that of the latter, 0·9674.
[3] For September, 1860, p. 165.

ART. XXIV.—*On the best Mode of presenting, in a popular form, the Theory of the Tides, with suggestions for constructing illustrative apparatus;* by WILLIAM DENNIS, Philadelphia, Pa.

IT is remarked by Sir J. Herschel that "many persons find a strange difficulty in conceiving how they (the tides) are produced;" and Mrs. Somerville goes so far as to say (*Physical Sciences*, C. 13), that among those classed as astronomical problems this "is by far the most difficult and its explanation the least satisfactory." This latter statement is perhaps rather broad as it stands, but if it were limited somewhat, so that the singularity of the phenomenon and the importance and familiar interest that attach to it and to its effects should be taken into account, it would scarcely require further qualification. It can hardly be denied that an intelligent comprehension of this subject is rare even among those to whom the causes of most natural phenomena are familiar, while to the great majority of intelligent people it is altogether a mystery. It seems, therefore, worth while to enquire whether the difficulties complained of have been reduced to a minimum, or whether they be not in part owing to defects or errors in the usual mode of presenting the explanation.

Having had occasion, in the preparation of a new elementary treatise on astronomy, to consider this subject attentively, as well as to examine the explanations commonly given, I have been compelled to conclude that no small portion of the obscurity and perplexity commonly supposed to belong to this subject arises from the want of a proper consideration and statement of the conditions and circumstances under which the causes producing the phenomenon act. If a learner be told, (and for whom are explanations intended if not for learners?) that the waters of the ocean are raised by the moon's attraction, his first idea, in many cases, will be that they are lifted up *by main strength*, as it were, the force of gravity being *overcome*,[1] and having no where observed any similar effect of the moon's attraction, he cannot conceive how this can be. Nor will it tend in any degree to lessen his perplexity if he shall see it stated, (as he may,) that according to Newton's calculations, the *disturbing* power of the moon's attraction on the surface of the earth is less than a ten-millionth part of the force of gravity, and that of the sun's attraction not even half as great as it. It is therefore important to show, by a preliminary explanation, that the waters of the

[1] An idea akin to this must exist, it would seem, in the minds of those authors who speak of the *lateral* attraction of the moon at a given place after or before its passing the meridian of that place; as if this *disturbing* force, so minute at its greatest, and in respect of this lateral action, so greatly reduced by its very oblique direction, or else by the near approach of the place in question to the *mean distance* could ever produce any appreciable effect whatever in that way.

ocean, in their general figure and outline, are in a state of perfect equilibrium or perfectly balanced, so that, in view of this, and of their vast extent and perfect freedom of motion, they may be compared to a scale-beam in perfect equipoise, suspended in the most delicate manner, and *several thousand miles in length.* To omit this would be much the same as if one should state, in proof and illustration of the attraction of gravitation, that a weight or ball at the side of a mountain had been observed, (referring to the Schehallien experiment,) to be drawn towards the mountain by its attraction, leaving the learner to suppose that the weight was placed on a table or other level surface instead of being suspended by a long thread or wire.

In explaining this condition of equilibrium the most obvious course will be to refer to mere hydrostatic equilibrium, in which any portion of these waters may be regarded as exactly balanced by any other contiguous portion, each being maintained at its level by the pressure of the other which supports it: consequently if this pressure be, in the case of either portion, lessened or increased *in the least degree*, that is to say, if the force of gravity, to which this pressure is due, be in any degree counteracted or added to by any other force in one of these portions and not in the other; the lighter portion will immediately give way and be buoyed up by the heavier which will of course simultaneously sink: and this would be an explanation sufficient for the purpose. But as this statement, though true, is not the whole truth, it may be well to go a step further. The waters of the ocean do not maintain their general figure and outline under the influence of gravity alone. On the contrary it is well known that by the centrifugal force generated by the earth's rotation on its axis they are kept at a higher level or greater distance from the centre on other parts of the globe than at the poles, this elevation amounting at the equator where it is greatest to about 13 miles. They are therefore exactly suspended or poised between these two forces, namely, the force of gravity and the centrifugal force just mentioned, and any other force that should in the least degree add to or counteract the influence of either of these forces would at once cause a change in the figure of these waters. While therefore it is properly the hydrostatic equilibrium existing between the different portions of the waters themselves that is disturbed by the action of the forces that produce the tides, the statement just made may serve to show more clearly how far these waters are, in their normal condition, from lying as a *dead weight* in the depressions of the earth's surface that contain them.

Again it is stated in a familiar way, (see *Chambers Hand-B. of Astron.*, *Bouvier's Famil. Astron.*, et al.,) that the tide on the side of the earth towards the moon is owing to the waters there being attracted by it more than the mass of the earth because they are

nearer, while the tide raised at the same time on the opposite side of the earth results from the earth being drawn away from the waters there because they are more remote than the mass of the earth and are thus "left behind," or "left heaped up;" and then we are told that at full moon, when the attractions of the sun and moon are *opposite* in direction, they conspire to produce spring tides in the same manner as at new moon when their attractions coincide in direction. Now as it is not easy to see how a body can be drawn away so as to leave any thing behind in two opposite directions at the same time, these statements appear quite inconsistent and are well calculated to confuse and perplex. It is therefore important and indeed indispensable to the communication of an intelligible view of this phenomenon to explain, as before remarked, the conditions and circumstances, or, to express it more definitely, the relations and dependencies existing among the bodies concerned in it: a course at once so natural and so needful that it seems remarkable that it should not have been more generally and more fully adopted.

As the earth is *held* to its curved path around the sun by the attraction of that body acting in opposition to the centrifugal force generated by its rapid motion, in the same manner that a heavy ball or weight attached to the end of a cord and whirled around the head is held or restrained by the cord, we may regard it as suspended between these two forces, and if a ball be merely suspended by a cord it will be a fair illustration of its condition; the force of gravity or weight of the ball standing in place of the centrifugal force in the case of the earth, and the tension of the cord representing the restraining force of the sun's attraction which at each instant holds the earth to the place in its orbit which it occupies. But as this attraction of the sun diminishes rapidly with an increase of distance it is plain that it cannot hold *all parts* of the earth alike or equally, the nearest part being about 8,000 miles less distant than the most remote, while of course it holds *the whole as a mass* as it would hold it were it at the *mean* distance of all the parts, that is, at the distance of the centre. Consequently on the nearest part or side towards the sun the attractive force being greater than the mean, there will be a small *excess* over what is sufficient to hold *this part* to its place in the orbit, and this excess acting upon the surface waters there in opposition to the force of gravity renders them specifically lighter and the exact equilibrium before described is immediately disturbed: these waters will therefore rise somewhat while those that are so situated as to be unaffected by this disturbing influence will sink simply from the *giving way* of those which having become lighter yield to their superior pressure. Again on the opposite side of the earth or that most remote from the sun, the attractive or restraining force will be less

than the mean and therefore not quite equal to the centrifugal force and here accordingly there will be an excess of this latter force: but on this side it is this centrifugal force that acts in a direction opposite to that of gravity, and this *excess* of it will consequently disturb the equilibrium of the surface waters here in precisely the same manner as in the other case.

Referring now, for illustration, to the suspended ball before mentioned, let us suppose it to be a hollow globe one or two feet in diameter, of a quite flexible material, as India rubber, having an opening about half an inch in diameter at the top and also at the bottom: let the principal suspending cord pass through the top so as to be attached at the centre to the intersection of two stiff horizontal wires, which are placed at right angles to each other and the extremities of which pass *loosely* through small openings in the sides of the globe. Passing this cord over a pulley and attaching a weight, so adjust the weight that it shall be sufficient to support the *middle* horizontal zone or segment of the globe. Let there be two other cords with pulleys and attach one to the top of the globe and the other to the bottom, the latter passing down through the opening in the top; then attach to the former a weight *somewhat more than* sufficient to support the top part of the flexible globe and to the latter a weight *not quite* sufficient to support the bottom part. Now it should be remembered that in this illustration the force of gravity or weight of the globe stands in place of the centrifugal force generated by the earth's motion in its orbit, and the tension of the cords, in place of the sun's attractive force varying at different distances: the cord attached to the wires at the centre may then represent the mean attractive force of the sun at the mean distance, as by this the globe is mainly held to its place, while the greater of the other two weights, being a little more than sufficient to support the part upon which it acts, will represent the attractive force acting upon the part of the earth nearest the sun, and the smaller weight, not quite sufficient for the same purpose, will represent the attractive force acting upon the opposite or most remote side. The globe being flexible, it is evident that the top part will be drawn up somewhat by the *excess* of the weight connected with it, while the bottom part will sink from the *deficiency* of its counterpoise and the whole will be elongated vertically and *for that reason* contracted horizontally. In like manner is the earth, in its yielding portions, the waters, elongated in one direction, that is, in the direction of the attracting or restraining force of the sun, and for that reason contracted in the direction at right angles to that.

Such is a statement of the general principle upon which the attraction of the sun (or of the moon) tends to produce a tidal

elevation on two opposite sides of the earth with intermediate depressions; and I prefer taking the case of the sun for this statement because the relations upon which this phenomenon depends are in general better understood or at least are more familiar to most as they exist between the earth and the sun than the same sort of relations between the earth and the moon.

Indeed, the sun being the great central power which controls the general motions of both the earth and the moon, there seems to be a manifest propriety in commencing with its influence, and, for the same reason, it will doubtless seem to many at first sight that it should be the chief and controlling cause of the tides. But this is not the case. The disturbing influence of the attracting body depends, not on the difference simply between the distance of the centre of the earth from it and that of the nearest or most remote side, but on this difference as *compared with the whole distance.* Now this difference in the case of the moon is about one-sixtieth part of the whole distance, but in the case of the sun it is less than a twenty-thousandth part, and hence it happens that while the attractive force of the moon is quite small compared with that of the sun, its *disturbing influence* is about two and one-half times that of the larger body.

Accordingly it is found that the moon exercises a *controlling* power over the tides, and the influence of the sun appears only in *modifying* the effects which it produces. We have now therefore to consider the case of the earth and the moon and to apply to it the principle already explained.

If it were a tide upon the moon that we are to explain, the complete analogy between this case and that of the earth and the sun would be at once recognized, the revolution of the moon around the earth being a fact as familiar to most as that of the earth around the sun. But action and reaction being always equal, while the earth *holds* the moon to its course or orbit in opposition to the centrifugal force, the earth itself is in like manner attracted and held by the moon to an extent proportioned to its inferior size or mass, and the consequence is that both bodies revolve about their common centre of gravity, that is, about a point between them which is as much farther from the centre of the moon than it is from the centre of the earth as the earth is heavier than the moon. That this point is comparatively near the centre of the earth, even nearer than (or within) the surface, in no way affects the operation of the causes which produce the phenomenon under consideration; but it is important to guard against what seems to be a very common misconception of the revolution of the earth about this point. This material error consists in supposing that point in the earth where this centre lies, or which coincides with this centre at any instant, to be *stationary* as regards this revolution, while the other parts of the

earth revolve about it; whereas, it is a revolution of the centre of the earth around this common centre of gravity, every point in the surface or elsewhere having a *corresponding motion:* it is not a revolution of the *parts* of the earth about a point within it which remains fixed, but a revolution of the earth *as a mass* about a certain point lying between its centre and that of the moon. This being understood, the case of the earth and the moon may be regarded as precisely analogous to that of the sun and the earth as already explained: in performing its revolution in this narrow orbit, (its diameter is about 5,400 miles,) the earth is held to a curvilinear motion in opposition to the centrifugal force by the moon's attraction, in the same manner that it is held to its larger orbit by the sun's, and there is consequently a corresponding *excess* of the attractive force over the mean and therefore over the centrifugal force on the side of the earth towards the moon, and a corresponding *deficiency* of attraction and consequent excess of centrifugal force on the opposite side. Hence, there must result, as in the former case, a disturbance of the equilibrium of the surface waters—a tendency in those on these two sides to rise to a higher level, and a consequent depression of those portions not affected by this disturbing influence. The illustrative apparatus, described in reference to the sun's action, is evidently equally applicable to this case. If it be thought desirable to render the representation more exact by exhibiting a *greater* effect than that produced for the case of the sun, it will only be necessary to increase the difference between the weight attached to the top and that connected with the bottom by reducing the latter and adding to the former.

It has been already stated that, in consequence of the comparative nearness of the moon to the earth, its attraction is the chief and *controlling* cause of the tides, but the sun, although its distance is 400 times as great, has yet sufficient influence to modify materially the effects which the smaller body tends to produce: it remains to show how these two causes operate in combination, or, in other words, how the effect produced by the moon as principal is modified by the action of the sun as accessory. Taking, first, the case of the two bodies being in conjunction at new moon, it is easy to see that, as they are both on the same side of the earth, their attractions have the same general direction and must therefore conspire to produce the same effect which will of course be an exaggerated one: hence the spring tides that are observed about the time of new moon. Nor is what has been already stated in relation to the earth's being held to its place by the sun's attraction in any way inconsistent with this result. It is still held by the sun, and with the same force, but the attraction of the moon is *added* to that of the sun and it is thus not merely *held*, but actually drawn out of the course which it would

have taken under the influence of the sun's attraction alone and brought for the time somewhat nearer to the sun.

Again, when the two attracting bodies are on opposite sides of the earth at full moon, it will be found that the result should be the same; for the earth is still held, and its two opposite sides *unequally* held, by the sun's attraction, which thus produces an elongation, or a tendency to elongation, in the manner before described: at the same time it is drawn, and these two sides unequally drawn, in the opposite direction by the moon's attraction; and as the side that is held least firmly by the sun is the one most attracted by the moon, and *vice versa*, this action of the moon will also tend to produce a further elongation in the same direction. Hence, these separate actions combine and produce an increased result, which appears in the spring tides belonging to the full moon. Nor can the separate *influences* of the sun and moon, (as it is important to note,) in any degree counteract or interfere with each other. Their *effects* may be combined, opposed, or mutually modified, according to the circumstances of each particular case, but the tendency of each of these attracting bodies, so far as the phenomenon under consideration is concerned, is to produce its own specific effect, and this *tendency* is in no way materially affected by the position or action of the other at the same time. To be satisfied of this, we have only to observe that the earth is at all times and under all circumstances held suspended by the sun's attraction without regard to the moon's position or action upon it. While thus held or suspended, the moon by its attraction draws it somewhat out of the course it would otherwise pursue, bringing it now a little nearer to the sun and then taking it a little farther from it, at one time hurrying it onward and again retarding it somewhat, (movements necessarily resulting from that revolution of the earth about the common centre of gravity of itself and the moon before explained); but this *by-play* between the earth and the moon in no way essentially affects the relation existing between the earth and the sun: the former unceasingly pursues its orbital course around the latter, which must therefore constantly hold it suspended by its attraction as already described.

The case in which the sun's and moon's attractions being in the same direction (at new moon) conspire to produce a greater effect, namely, the spring tides of new moon, seems hardly to require separate illustration. It is as if the power of one of these bodies were temporarily increased, which would of course produce an increased result. It may however be illustrated by a modification of the apparatus before described. Let the flexible globe be suspended by three weights with pulleys, representing as in a former case the sun's attraction, the weights being now connected with the several parts of the globe by *elastic* cords or bands, and

when the suspension is completed *clamp* the cords at the pulleys; they will then represent the constant action of the sun and at the same time allow the whole globe or any of its parts to move to a limited extent under the action of another force. By means of three other cords with pulleys, attach three additional weights to the same points to act in the same direction and thus to represent the *added* attraction of the moon; and by a proper adjustment of the second set of weights, and of the size or elastic force of the first set of cords, not only the increased elongation of the earth (the spring tides) belonging to this position of the other bodies, but its temporary approach to the sun, may be represented.

In the other case described, in which the attractions of the sun and moon are opposite in direction, (at full moon,) and still conspire to produce an increased result, some illustration may perhaps be more needful, and it is readily supplied by a further modification of the apparatus arranged as last described. Let the globe be suspended by the three elastic cords representing the sun's attraction, and clamped as before; but as these act upward, and the moon's attraction is now supposed to be opposite in direction to that of the sun, it may be represented by weights attached to the globe *directly* and acting downward: attach, therefore, in this manner, the other three weights to the bottom, the top, and the centre, respectively, to represent the attractive force of the moon at those three distances, and as the lower side of the globe now represents the side of the earth toward the moon acting from below, as the sun from above, it is obvious that the weight attached to the bottom must in this case be greater than that attached to the top. Now it is evident that under this arrangement of the forces the elongation of the globe must be increased by the addition of the second set of weights, and in like manner does the combined attractions of the sun and moon, though opposite in direction, produce the increased effect observed in the spring tides of full moon.

At the first and last quarters of the moon the direction of the sun's attraction is at right angles to that of the moon, and its disturbing influence must therefore act upon the equatorial portions of the earth's surface intermediate to those acted upon by the moon at the same time. Now we have seen that the effect of the disturbing influence of these bodies is to render the surface waters upon which it acts specifically lighter, and thus to disturb the exact equilibrium that would otherwise exist; these lighter portions being buoyed up to a higher level by those portions not so affected, which of course at the same time sink. But in the case we are now considering, while the moon's influence is producing the lunar tide on two opposite sides of the earth, the sun is at the same time acting upon the intermediate equa-

torial spaces and is thus diminishing to the extent of its influence the gravity of those very portions upon the weight of which the lunar tide in part depends.[2] The lunar tide will consequently be lessened by this action of the sun's influence, and hence the neap tides of the moon's first and last quarters. These neap tides may also be illustrated by the flexible globe; for if we have it merely suspended by three weights, as at first, but representing now the moon's attraction, and attach to two opposite sides two other weights with pulleys acting in a horizontal direction, these last may be regarded as representing the disturbing influence of the sun which acts *from the centre*, or in opposition to gravity on two opposite sides of the earth. Now these two weights, by drawing the two sides to which they are respectively attached nearer to their normal position or distance from the centre, or, in other words, by tending to elongate the globe in a direction at right angles to that of the moon's attraction, will lessen somewhat the vertical or lunar elongation.

In the intermediate positions, or between new moon and the first quarter, this quarter and full moon, and so on, the influence of the sun will vary from what it is at one of these extreme or turning points to what it is at the next; but to describe these changes—and the same may be said of numerous subordinate or collateral branches of this subject—does not fall within the scope of my present purpose; which was merely to point out a mode of presenting the essential features of the theory of the tides, calculated, as it seemed to me, to make it more easily and more fully understood than those in common use, and also to suggest some ocular illustrations.

[2] It will be observed that I say "in part," and speak above of "equatorial spaces," etc. There seems to be good reason to doubt whether in this connection one circumstance has been by any means properly attended to, namely, that the lunar tide may be raised in part, perhaps in some cases chiefly, by the pressure of those portions of the surface waters lying northward or southward of the central points of the moon's direct influence; these would be for the most part wholly undisturbed by the sun's influence. A lunar spheroidal wave is formed *theoretically* by pressure on *all* sides: the sun can materially interfere with its formation only on *two* (opposite) sides, namely, where the two antipodal centres of its influence approach, or fall upon, the edge of the wave. The theoretical proportion between spring and neap tides has been commonly, (not to say carelessly,) stated as that between the sum and *difference* of the two separate disturbing influences of the sun and moon, say as 7 to 3; but even theoretically this is manifestly incorrect, and, in point of fact, so far as I have observed, on the western shore of the North Atlantic, it does not approximate to the truth. Here, indeed, this northern and southern influence would seem to have freest scope, and in view of the eastern and western *boundaries* of this ocean, it seems not unlikely that it would be more consistent with the actual facts of the case to consider the neap tides *here* as the lunar tide *alone*, and the spring tides as the lunar and solar combined.

ART. XXV.—*Analysis of a Meteorite from Chili;* by CHARLES A. JOY, Professor of Chemistry in Columbia College, New York.

THIS meteorite was found on a mountain pass, about fifty miles from Copiapo, in the province of Atacama, Chili, by a native of the Argentine Republic, and presented to Mr. Joseph Brower, by whom it was brought to New York, and to whose kindness I am indebted for the fragment used in the analysis. The original specimen has been deposited by Mr. Brower, with a large collection of rare silver and copper ores from Chili, in the mineralogical cabinet at Union College, Schenectady.

The outer crust of the meteorite wore the usual dark red color of oxydized iron. Its weight, uncut, was 1784 grams. The specific gravity is 4·35. A polished etched surface gave an impression on paper of scattered points rather than of regular lines. It also readily reduced copper from its solutions.

A close inspection of the specimen shewed that there was a large per-centage of stony matter interspersed through the mass. The color and hardness of a portion of this indicated olivine; other fragments recalled the appearance of partially decomposed labradorite. An unsuccessful attempt was made to withdraw the iron by means of a magnet, but the powdered mineral adhered to the magnet in association with the iron.

For the determination of the sulphur, phosphorus, copper and tin, the presence of which had been revealed by a qualitative analysis, a large fragment was taken and treated with aqua regia, at a gentle heat. The sulphur separated in finely divided grains, and care was taken to prevent them from combining into compact masses. After gently heating in a water-bath for twenty-four hours, all of the sulphur was successfully oxydized. The portion of the meteorite insoluble in acids was collected upon a filter, dried, incinerated and weighed. From the solution, sulphuric acid was precipitated by chlorid of barium, the precipitate was heated with chlorhydric acid to free it from all traces of iron, filtered, dried and weighed. The filtrate from the sulphate of baryta gave a slight brown precipitate with sulphuretted hydrogen. This was dissolved in aqua regia, and saturated with ammonia, when a slight yellow precipitate of tin was thrown down, while copper was dissolved and afterward precipitated by potash.

After expelling the sulphuretted hydrogen from the first filtrate, the phosphorus was separated by molybdate of ammonia and afterward determined as phosphate of magnesia.

For the determination of the iron, alumina, nickel, cobalt, manganese, and lime, a second portion was taken and treated as before. The iron, alumina, nickel, cobalt, and manganese were successively precipitated by ammonia and sulphid of ammonium

and the precipitate redissolved and weighed. The iron and alumina were separated from the other bases by carbonate of baryta. The nickel, cobalt, and manganese, were not determined in this portion, but were precipitated by potash and weighed. The separation of the iron and alumina was accomplished by means of the hyposulphite of soda. The alumina was found to be free from the oxyd of chromium. The lime was determined as carbonate. For the separation of the nickel and cobalt from manganese, in another portion, the insolubility of the sulphids of nickel and cobalt in chlorhydric acid was used. To separate nickel and cobalt, I preferred the method of chlorine and carbonate of baryta which I had followed in Rose's laboratory. Liebig's process, which I employed with the Cosby Creek iron,[1] was inconvenient, and the method by nitrite of potassa did not yield satisfactory results, owing to impure materials and want of time to repeat the analysis.

Results:

From 3·519 grams.		1·134 grms. insol.		2·385 grms. soluble.
	BaO, SO_3	0·688		0·0944 S
	MgO_2PO_5	0·015		0·00423 P
	CuO	0·002		0·00159 Cu
	SnO_2	0·001		0·001 SnO_2
No. 3.	Mn_3O_4	0·011	No. 2.	1·166 grms. material.
	Co_3O_4	0·021		0·390 grms. insoluble.
	NiO	0·124		0·776 " soluble.
		0·156		
	CaO, CO_2	0·025		0·014 CaO
	Fe_2O_3	0·859		0·6013 Fe
	Al_2O_3	0·039		0·039 Al_2O_3
	Mn_3O_4	0·006		0·00432 Mn
	NiO	0·077		0·06034 Ni (Calc. from No. 3.)
	Co_3O_4	0·013		0·00959 Co

From the above figures we obtain the following results:

Fe	77·48 pr. ct.
Ni	7·77 "
Co	1·23 "
Mn	0·55 "
CaO	1·80 "
Al_2O_3	5·02 "
S	3·95 "
P	0·17 "
Cu	0·06 "
SnO_2	0·04 "
	98·07

[1] Ann. Chem. Pharm., lxxxvi, 39.

As the analysis was conducted with great care, and as we have alumina and lime evidently derived from the decomposition of a portion of the mineral, and as protoxyd of iron is easily attacked in silicates, it is proper to assume that the difference is due to oxygen combined with iron as protoxyd. Assuming 1·90 pr. ct. oxygen, we require 6·65 pr. ct. Fe to form 8·55 FeO. This will give us for the soluble portion:

Fe	70·83 pr. ct.	Mn	0·55 pr. ct.
Ni	7·77	Al_2O_3	5·02
Co	1·23	FeO	8·55
Cu	0·06	CaO	1·80
S	3·95	SnO_2	0·04
P	0·17		99·97

The average of several analyses gave 68·19 pr. ct. soluble in acids, and 31·81 pr. ct. insoluble in acids.

Insoluble mineral portion.

This was fused with carbonate of soda: an intense green color indicated the presence of manganese. The fused mass treated with water yielded a green solution of NaO, MnO_3, which turned red upon further heating, and colorless upon addition of alcohol. The solution was evaporated to dryness and the silica separated as usual. It was afterwards fused by itself and found to be pure and to contain no undecomposed mineral. Sulphuretted hydrogen was passed through the filtrate from the silica, by which a slight precipitate of a brown sulphid was produced. This was collected upon a filter, dried, treated with a few drops of aqua regia, incinerated and weighed. It was then nearly all dissolved in chlorhydric acid. Ammonia produced a yellow white precipitate of SnO_2, HO which becomes brown in NH_4S and was dissolved in an excess of that reagent and upon addition of HCl yielded brown sulphid of tin. The ammoniacal filtrate from SnO_2 was colored distinctly blue by copper.

The filtrate from the sulphid of tin and sulphid of copper was treated with chlorid of ammonium and ammonia and saturated with sulphid of ammonium and heated, by which iron, manganese, nickel, cobalt, and chromium were precipitated. This precipitate was dissolved in aqua regia. From the filtrate from the sulphur metals the lime was precipitated by oxalate of ammonia and the magnesia by phosphate of soda.

From the solution in aqua regia, the oxyds of iron, alumina, and chromium, were precipitated by carbonate of baryta in the cold. The excess of baryta was removed by sulphuric acid and the manganese precipitated by potash: this precipitate was examined for nickel and cobalt and found to contain traces.

The precipitate containing the oxyds of iron, alumina, and chromium, and excess of carbonate of baryta, was dissolved in chlorhydric acid, the baryta removed by sulphuric acid, and the iron and alumina separated by hyposulphite of soda.

The sesquioxyd of chromium was separated from the oxyds of iron and alumina, as follows: The Al_2O_3 was fused with NaO, Co_2 and KO, NO_5, the fused mass dissolved in water, saturated with chlorhydric acid and evaporated with additions of chlorate of potassa and the alumina precipitated with ammonia and the chromic acid as chromate of lead.

The Fe_2O_3 was also fused with carbonate of soda and nitrate of potassa, and the mass lixiviated with water, filtered, saturated with chlorhydric acid, alcohol added, heated to boiling, and the sesquioxyd of chromium precipitated by ammonia.

Results:

Substance taken = 0·518 grms.

Found, SiO_3	0·334 grms.	64·478 per cent.
FeO	0·0729	14·073
MgO	0·06737	13·005
MnO	0·01678	3·239
Cr_2O_3	0·00907	1·750–2·575 Cr_2O_3 FeO
Al_2O_3	0·00593	1·144
CaO	0·00448	0·864
SnO_2 + CuO	0·005	0·965
NiO, CoO	0·002	0·386
	0·51753	99·904

Second Analysis.

Substance taken = 1·114 grms.

Found, SiO_3	0·713	65·61 per cent.
MgO	0·1549	13·90
FeO	0·1647	14·78
Cr_2O_3	0·0140	1·25
Al_2O_3	0·0120	1·07
MnO	0·0325	2·91
CaO	0·0128	1·15
Ni, CO	0·0010	0·09
		100·76

Average.

SiO_3	65·04
MgO	13·45
FeO	14·42
Cr_2O_3	1·50
Al_2O_3	1·10
MnO	3·07
CaO	1·01
Ni, Co	0·23
	99·82

From these analyses we have the composition of the meteorite as a whole, as follows:

Fe	48·298	per cent.
Ni	5·298	
Co	0·838	
Mn	0·375	
Cu	0·040	
S	2·693	
P	0·115	
SiO_3	20·689	insoluble.
MnO	0·976	"
Cr_2O_3	0·477	"
NiO, CoO	0·073	"
FeO	5·830	soluble.
FeO	4·587	insoluble.
CaO	1·227	soluble.
CaO	0·321	insoluble.
Al_2O_3	3·423	soluble.
Al_2O_3	0·349	insoluble.
MgO	4·278	"
SnO_2	0·027	soluble.
SnO_2	0·162	insoluble.
	100·076	

Metallic portion.

Fe	48·298	per cent.
Ni	5·298	
Co	0·838	
Mn	0·375	
Cu	0·040	
S	2·693	
P	0·115	
	57·657	

Mineral portion.

SiO_3	20·689	per cent.	
MnO	0·976		
Cr_2O_3	0·477		
NiO, CoO	0·073		
FeO	10·417		
MgO	4·278		
Al_2O_3	3·772		
CaO	1·548	Another anal.	
SnO_2	0·189	0·332	
	42·419		

In 100 *parts.*

Metallic.		Mineral.		
Fe	83·76	SiO_3	48·61	
Ni	9·18	FeO	24·47	
Co	1·45	MgO	10·05	
Mn	0·65	Al_2O_3	8·86	
Cu	0·07	CaO	3·63	
P	0·20	MnO	2·29	
S	4·67 (12·84 FeS.)	Cr_2O_3	1·12	
		NiO, CoO	0·17	Another anal.
		SnO_2	0·44	0·78
	99·98		99·64	

If we examine the mineral portion under a microscope and study its behavior towards reagents, we shall find at least two silicates in the meteorite; one of them, like olivine, having the formula $RO_3\,SiO_3$, not so easily attacked by acids, and the other resembling labradorite, with the formula $x\,R_2O_3\,SiO_3 + y\,RO\,SiO_3$. Assuming that the Cr_2O_3 was combined with the FeO as chrome iron, the 1·12 Cr_2O_3 will require 0·52 FeO, which must be deducted from the 24·47 pr. ct. FeO. Assigning MgO, MnO, NiO, CoO, to the mineral RO^3, SiO_3 and the Al_2O_3, CaO, to the mineral $x\,R_2O_3\,SiO_3 + y\,RO\,SiO_3$, and dividing the FeO between them, we have for the mineral portion:

Chrome iron - -	1·64 pr. ct.	Cr_2O_3 FeO	
Olivine, - -	27·43	$RO_3\,SiO_3$	
Labradorite - -	70·13	$Al_2O_3\,SiO_3$	$+4RO\,SiO_3$
	99·20		

This will give for the composition of the meteorite:

Nickel iron (with Co, Mn, and Cu)	48·689
Sulphid of iron, FeS	7·405
Chrome iron, Cr_2O_3 FeO	0·701
Schreibersite, (Fe 1·38, Ni 0·67, P 0·115)	1·563
Olivine, $RO_3\,SiO_3$	11·677
Labradorite,* (R_2O_3, $SiO_3 + 4RO\,SiO_3$)	29·852
Tin stone, SnO_2	0·189
	100·076

Calculations were made referring the silicates to hornblende, hypersthene, augite, and anorthite, but I omit them in the summary as being of a purely theoretical character. The above is believed to give the fair average constitution of this meteorite.

I must express my obligation to my assistant, Mr. Charles A. Stetefeldt, for skillful aid in hastening the completion of the analysis.

New York, Jan. 1st, 1864.

ART. XXVI.—*Contributions to Lithology;* by T. STERRY HUNT, M.A., F.R.S.; of the Geological Survey of Canada.

I. *Theoretical Notions.*—II. *Classification and Nomenclature.*

In a recent paper on *The Chemical and Mineralogical Relations of Metamorphic Rocks* (this *Journal*, [2] xxxvi, 214), an attempt was made to define the principles which have presided over the formation of sedimentary rocks, and to explain the nature and conditions of their alteration or metamorphism. That paper

* The absence of soda is disregarded in the calculation of the formula.

may be considered as to a certain extent introductory to the present one, which will contain, in the first part, some theoretical considerations which it is conceived should serve as a basis to lithological studies. In the second part will be given a few definitions which may serve to render more intelligible the classification and nomenclature of crystalline rocks; while a third part will contain the results of the chemical and mineralogical examination of some of the eruptive rocks of Canada. These results will be found for the most part in the recently published volume entitled the *Geology of Canada.*

I.

I have already, in other places, expressed the opinion that the various eruptive rocks have had no other origin than the softening and displacement of sedimentary deposits; and have thus their sources within the lower portions of the earth's stratified covering, and not beneath it. The theory which conceives them to have been derived from a portion of the interior of the earth still retaining its supposed primitive condition of igneous fluidity, is in my opinion untenable. It is not here the place to discuss the more or less ingenious speculations of Phillips, Durocher, and Bunsen as to the constitution of this supposed fluid centre, nor the more elaborate hypothesis of Sartorius von Waltershausen as to the composition and arrangement of the matters in this imaginary reservoir of plutonic rocks. The immense variety presented in the composition of eruptive masses presents a strong argument against the notion that they are derived, as these writers have supposed, from two or more zones of molten matter, differing in composition and density, and lying everywhere beneath the solid crust of the earth; which, in opposition to the views of many modern mathematicians and physicists, the school of geologists just referred to regard as a shell of very limited thickness.

The view which I adopt is one the merit of which belongs, I believe, to Christian Keferstein, who, in his *Naturgeschichte des Erdkörpers,* published in 1834, maintained that all the unstratified rocks, from granite to lava, are products of the transformation of sedimentary strata, in part very recent; and that there is no well defined line to be drawn between neptunian and volcanic rocks, since they pass into each other, (vol. i, p. 109). This view was subsequently, and it would seem, independently brought forward in 1836 by Sir John Herschel, who sought to explain the origin of metamorphism and of volcanic phenomena by the action of the internal heat of the earth upon deeply buried sediments impregnated with water. (*Proc. Geol. Soc.* of London, vol. ii, pp. 548, 596.) See also my papers in the *Canadian Journal,* 1858, p. 206; *Quart. Jour. Geol. Soc.* 1859, p. 488; *Can. Naturalist,* Dec. 1859, and *this Journal,* [2], vol. xxx, p. 135.

The presence of water in igneous rocks, and the part which it may play in giving liquidity to all volcanic and plutonic rocks was insisted upon by Poulett Scrope, so long ago as 1824, in his *Considerations on Volcanos*, (see also *Quart. Jour. Geol. Soc.* London, xii, 341.) This view has since been ably supported by Scheerer in his discussion with Durocher. (*Bul. Soc. Geol. France*, [2], iv, 468, 1018; vi, 644; vii, 276; viii, 500.) See also Elie de Beaumont, *ibid.*, iv, 1312. The admirable investigations of Sorby on the microscopic structure of crystals, (*Quart. Jour. Geol. Soc.*, xiv, 453) have since demonstrated that water has intervened in the crystallization of almost all plutonic rocks. He has shown the quartz both of granites and of crystalline schists contains great numbers of small cavities partially filled with water, or with concentrated aqueous solutions of chlorids and sulphates of potassium, sodium, calcium and magnesium, sometimes with free chlorhydric acid. Similar fluid cavities were found by him in most crystals artificially formed in aqueous solutions, and were also observed in the minerals from the limestones of Vesuvius, where they occur in nepheline, idocrase, hornblende and feldspar; the liquid in the latter crystals containing, besides chlorids and sulphates, alkaline carbonates. Mr. Sorby has also described the cavities filled with vitreous and with stony matters which he has observed in quartz, in the feldspar of pitchstones, in augite, leucite and nepheline; and which are sometimes found associated with fluid-cavities in the same mineral. As these fluid-cavities enclosed the liquid at an elevated temperature, its subsequent cooling has produced a partial vacuum, which is again filled on heating the crystal; so that the temperature of the crystals at the time of their formation may be approximatively determined. Mr. Sorby concludes that every peculiarity in the structure of the quartz of the veins in Cornwall, "may be most completely explained by supposing that this mineral was deposited from water holding various salts and acids in solution, at temperatures varying from 200° C. to a dull red heat visible in the dark" (about 340° C.) At this highest temperature he conceives that other minerals, such as mica, feldspar and tinstone were deposited, the latter mineral containing numerous small fluid-cavities. In like manner, he deduces from the fluid-cavities in the Vesuvian minerals just noticed, a temperature of from 360° to 380° C. The presence, at the same time, of bubbles or vapor-cavities and of glass and stone-cavities in these crystals shows them to have been formed "at a dull red heat under a pressure equal to several thousand feet of rock, when water containing a large quantity of alkaline salts in solution was present, along with melted rock, and various gases and vapors. * * * * I therefore think that we must conclude provisionally, that at a great depth from the surface, at the foci of

volcanic activity, liquid water is present along with the melted rocks, and that it produces results which would not otherwise occur." (*loc. cit.*, p. 483.)

Mr. Sorby has, as we have just seen, determined the temperature requisite to expand the liquid so as to fill the fluid-cavities, provided they were formed under a pressure not greater than the elastic force of the vapor. This of course represents the lowest temperature at which the consolidation could have taken place, and varies from 340° to 380° in the Vesuvian minerals, and 356° in the quartz of the trachyte of Ponza, to a mean of 216° in the Cornish granites, to 99° in those of the Scottish Highlands, and even descends to 89° in some parts of the granite of Aberdeen. But this low temperature is improbable, and inasmuch as water and aqueous solutions are compressible, their volume would be considerably reduced under a great pressure of superincumbent rock. Mr. Sorby has therefore calculated the pressure in feet of rock which would be required to compress the liquid so much that it would just fill the cavities at 360° C. The numbers thus obtained will therefore represent the actual pressure, provided the rock was in each case consolidated at that temperature. It would thus appear that the trachyte of Ponza was solidified near the surface, or beneath a pressure of only 4000 feet of rock; while for the Aberdeen granite the pressure was equal to not less than 78,000 feet, and for the mean of the Highland granites 76,000. The Cornish granites vary from 32,400 to 63,600, and give, as a mean, 50,000 feet of pressure. In this connection Mr. Sorby remarks that from Mr. Robert Hunt's observations on the mean increase of temperature in the mines of Cornwall, a heat of 360° C. would be attained at a depth of 53,500 feet.

The observations upon the metamorphic crystalline schists in the vicinity of these various granites show that their constituent minerals must have crystallized at about the same temperature as the granite itself; affording, as Mr. Sorby observes, "a strong argument in favor of the supposition that the temperature concerned in the normal metamorphism of gneissoid rocks was due to their having been at a sufficiently great depth beneath superincumbent strata;" and he concludes that with regard to rocks and minerals formed at high temperatures, we have "at one end of the chain erupted lavas, indicating as perfect and complete fusion as the slags of furnaces, and at the other end simple quartz veins, having a structure precisely analogous to that of crystals deposited from water. Between these there is every connecting link, and the central link is granite." When the water, which at great depths was associated with the melted rock, was given off as vapor while the mass remained fused, slag-like lavas resulted. If however the water could not escape in

vapor, it remained, as we have seen, to take its part in the crystallization, in some cases forming hydrated minerals; and the excess of it, as Mr. Sorby suggests, passed up as a highly heated liquid, holding dissolved materials, which would afterwards be deposited in the form of mineral veins in the fissures of superincumbent rocks.

I have thought it well to give at some length the remarkable results and conclusions by Mr. Sorby, because I conceive that they have not as yet received the full degree of consideration to which they are entitled, and are perhaps little known to some of my readers.[1] The temperature deduced by him from the examination of the crystals of hornblende and feldspar from Vesuvius is curiously supported by the experiments of Daubrée; who obtained crystallized pyroxene, feldspar and quartz, in presence of alkaline solutions, at a temperature of low redness; while De Senarmont crystallized quartz, fluor-spar and sulphate of barytes in presence of water, at temperatures between 200° and 300° C. At the same time the deposits from the thermal waters at Plombières show that crystalline hydrous silicates, such as apophyllite, harmotome, and chabazite, have formed at temperatures but little above 80° C.

We conceive that the deeply buried sedimentary strata, under the combined action of heat and water have, according to their composition, been rendered more or less plastic, and in many cases have lost to a greater or less degree the marks of their sedimentary origin, although still retaining their original stratigraphical position. In other cases they have been displaced, and by pressure forced among disrupted strata, thus assuming the form of eruptive rocks; which, becoming consolidated under a sufficient pressure, retain the same mineral characters as in the parent beds. It is only those rocks which, like lavas, have solidified at or near the surface of the earth, and consequently under feeble pressure, which present mineralogical characters dissimilar to those of the undisturbed crystalline sediments. With this exception the only distinction which can be drawn between stratified and unstratified masses must in most cases be based upon their position, and their relation to the adjacent rocks.

In view of these considerations I have, in previous papers, adopted for geological purposes a division of crystalline rocks into indigenous rocks, or sediments altered *in situ*, and exotic rocks, or sediments displaced and translated, forming eruptive and intrusive masses. Under the head of exotic rocks is however to be included another class of crystalline aggregates, which are for the most part distinguished by their structure from injected or intrusive masses. I refer to the accumulations which

[1] See further the late observations of Zirkel confirming those of Sorby, *Proc. Imp. Acad. Vienna*, March 12, 1863; in abstract in *Quart. Jour. Geol. Soc.*, vol. xix.

fill mineral veins, and which doubtless have been deposited from aqueous solutions. While their peculiar arrangement, with the predominance of quartz and non-silicated species, generally serves to distinguish the contents of these veins from those of injected plutonic rocks, there are not wanting cases in which the predominance of feldspar and mica gives rise to aggregates which have a certain resemblance to dikes of intrusive granite. From these, however, true veins are generally distinguished by the presence of minerals containing boron, fluorine, phosphorus, cæsium, rubidium, lithium, glucinum, zirconium, tin, columbium, etc.; elements which are rare, or are found only in minute quantities in the great mass of sediments, but are here accumulated by deposition from waters which have removed these elements from the sedimentary rocks and deposited them subsequently in fissures.

No one at the present day will probably be found to deny the plutonic origin of most non-stratified rocks, so that the once vexed questions of the neptunist and plutonist may be regarded as settled. If, however, we go back but a few years in the history of geology, it will be found that an eruptive origin was then claimed for many rocks which are now admitted to be indigenous. It is scarcely necessary to refer to the views of those who have maintained the exotic character of many quartzites and crystalline limestones, when a majority of writers, even to the present day, class serpentines, euphotides, and hyperites among eruptive rocks; although the experience of every field-geologist is accumulating, from year to year, a great mass of evidence in favor of the indigenous nature of all these rocks. The sedimentary and indigenous character of very many granites, syenites, and diorites, will now no longer be questioned. Thus we find, for example, that the melaphyres of the Tyrol, which, in Von Buch's too famous theory of dolomitization, were supposed to have been erupted together with magnesian vapors which affected the alteration of the adjacent limestones, have been shown by Fournet to be sediments of Carboniferous age, metamorphosed *in situ*,—indigenous rocks, which were altered before the Jurassic dolomites were deposited, (*Bul. Soc. Geol. France*, [2], vi, 506–516). In like manner we find Scipion Gras concluding from his researches on the anthracitic rocks of the Alps, that the serpentines, euphotides, porphyries, and spilites, which are there found associated with crystalline schists, are all of sedimentary origin, but have been so profoundly altered *in situ* as to have lost nearly all traces of sedimentary origin (*Ann. des Mines*, [5], v, 475). We might add that the tendency of recent investigations has been to show that the protogines, or granites of the summit of the Alps, are Tertiary strata altered in place; thus confirming the bold assertion made by Keferstein in

1834, that these granites are altered strata of *flysch*. (*This Journal*, [2], xxix, 123, 124.) Lesley's recent investigations of the granites of the White Mountains of New Hampshire, show them to be clearly stratified sedimentary deposits in nearly horizontal layers. (*American Mining Journal*, 1861, p. 99; this *Journal*, [2], xxxi, 403.) The ophites (amphibolites) of the Pyrenees, which by Dufrenoy and other French geologists, have been regarded as eruptive, and were by the former imagined to be in some mysterious manner related to the rock-salt and gypsum of the region, which he supposed to be, like the ophites, of posterior origin to the enclosing strata, (*Explic. de la Carte Geol. de France*, i, 95,) are according to a recent note by Virlet, not eruptive, but altered indigenous rocks, belonging, together with the associated gypsum and saliferous strata, to the Triassic series. (*Comptes Rendus de l'Acad.*, Aug. 1863, p. 232.)

It would be easy to multiply examples of this kind, which show that a careful study of very many of the crystalline rocks, hitherto regarded as eruptive, leads to the conclusion that they are really indigenous rocks. At the same time many of these indigenous rocks appear to have been at one time in a soft semi-fluid condition, which permitted movements obliterating the marks of sedimentary origin, and producing other results which show the passage into eruptive rocks. Thus the crystalline limestones of the Laurentian series in Canada are frequently interstratified with thin beds of gneiss and quartzite, both of which are often found broken, contorted, and even twisted spirally, in a manner which indicates great flexibility of the siliceous layers, as well as violent movements in the calcareous rock. The latter is in some cases found in the form of thin seams or considerable dykes among the adjacent broken siliceous strata, thus assuming for small distances, the characters of an intrusive rock. For some figures and descriptions illustrating these broken and distorted strata, see *Geology of Canada*, pp. 27, 28. We may also allude in this connection to the observations of Dr. Hitchcock among the altered strata of the Green Mountains, which seem to show that the pebbles of gneiss and quartz in certain conglomerate beds have been so softened as to have been flattened, laminated, and bent around each other. (*This Journal*, [2], xxxi, 372.) Hence, while the tendency of the various observations above cited is in favor of the indigenous character of many rocks hitherto regarded as eruptive, we have at the same time evidence that these rocks are occasionally displaced. We should not therefore on *a priori* grounds reject the assertion that any metamorphic sediment may sometimes occur in an exotic or intrusive form. A given rock, like limestone or diorite, may occur both as an indigenous and an exotic rock; and different portions of the same mass may be seen by different observers under such

unlike conditions that one may regard it as indigenous, and the other, with equal reason, may set it down as intrusive. It is evident then that to the lithologist, who examines rocks without reference to their geological relations, the question of the exotic or indigenous character of a given rock is, in most cases, one altogether foreign; and one which can frequently be decided only by the geologist in the field. Hence, although generally made a fundamental distinction in classification, it will be disregarded in the following sketch of the nomenclature of crystalline rocks.

I may here allude to a fact which I have already noticed, and tried to explain, (*this Journal*, [2], xxxi, 414, and xxxvi, 220, *note*,) that throughout the great metamorphic belt which constitutes the Appalachian chain, exotic rocks are comparatively rare, (at least in New England and Canada); but abound, on the contrary, among the unaltered strata on either side. Illustrations of this are seen in the valley of Lake Champlain, and in its northward continuation toward Montreal, in those of the Hudson and Connecticut, and in the northeastward continuation of the latter valley by Lake Memphramagog to the Bay of Chaleurs, which is marked throughout by intrusive granites. In accordance with the reasons already assigned for this distribution of exotic rocks it is probable that a similar condition of things will be found to exist in other regions; and that eruptive rocks will, as a general rule, be found among unaltered, rather than among metamorphic strata. It is of course possible that a crystallization of the sediments may in some cases take place subsequent to the eruption of foreign rocks into their midst. The rarity of intrusive rocks among crystalline strata, not less than the unaltered condition of sediments which are traversed by abundant intrusive masses, is a strong proof of the fallacy of the still generally received notion which connects metamorphism with the contiguity of eruptive rocks.

II.

It is proposed in this second part, to describe briefly the composition, structure and nomenclature of the various crystalline silicated rocks, considered without reference to the distinction between indigenous and intrusive masses. Comparatively few of these rocks are homogeneous, or consist of a single mineral species, and the names which have been applied to varying mixtures of different species are of course arbitrary; and as they have often been given without any previous mineralogical study it sometimes happens that, as in the case of the rocks composed of anorthic feldspars and pyroxene, different names have been proposed for varieties very closely related, or differing from one another only in texture or in structure.

The minerals essential to the composition of the rocks under consideration are few in number, and are as follows: quartz, orthoclase; a triclinic feldspar which may be albite, oligoclase, andesine, labradorite or anorthite; scapolite, leucite, nepheline, sodalite; natrolite, or some allied zeolite; iolite, garnet, epidote, wollastonite, hornblende, pyroxene, olivine, chloritoid, serpentine, diallage; muscovite, phlogopite, and some other micas; chlorite, and talc. To these may be added as accidental ingredients, the carbonates of lime, magnesia, and protoxyd of iron, together with magnetite, ilmenite and sphene. The silicates which, like tourmaline, beryl, zircon, spodumene, and lepidolite, contain considerable portions of the rarer elements, and often occur with quartz and feldspar in granitic veins, whose origin has already been alluded to, enter at most in very small quantity into great rock masses.

The varieties of structure in crystalline rocks are the more deserving of notice as they have led to a great multiplication of names. We may note first the granitoid structure, in which the mineral elements are distinctly crystalline, as in granite. From this, there is a gradual passage through granular into compact varieties of rock. Most of these are simply finely granular, and are rightly entitled to the distinction of crypto-crystalline; but others, like the pitchstones, obsidians and lavas, are apparently amorphous, and are natural glasses. In some cases the constituent minerals may be so arranged as to give a schistose or gneissoid form to a rock. This arrangement is generally to be looked upon as an evidence of stratification, but something similar is occasionally observed in eruptive masses. In the latter case it generally seems to arise from the arrangement of crystals during the movement of the half-liquid crystalline mass, but it may in some instances arise from the subsequent formation of crystals arranged in parallel planes.

See on this point Naumann *On the probable eruptive origin of several kinds of gneiss, etc.;* Leonhard and Bronn, *Neues Jahrbuch* for 1847, and Poulett Scrope, *Geol. Journal*, xii, 345. I consider however that their views are to be adopted with great reserve, and admitted only in a very few cases. The ribbanded structure of some porphyries and clinkstones, as noticed by Scrope, is undoubtedly the result of movements in the liquid mass, and the same is true of some of the granitoid dolorites to be described in the third part of this paper; but the eruptive origin assumed by Darwin, Naumann, and some others for great areas of gneiss and gneissoid granite, seems to a student of the crystalline rocks of this continent utterly untenable. As has been already remarked, the progress of each year's investigation restores to the category of indigenous rocks many of those previously regarded as eruptive, and will, I am convinced, confirm

the principle which I have laid down of the comparative rarity of exotic rocks in crystalline and metamorphic regions.

Occasionally the crystallization of a rock takes place around certain centres, giving rise to rounded masses which have a radiated or a concentric structure, and constitute the so-called globular or orbicular rocks. Distinct crystals of some minerals, generally feldspar, augite, or olivine, are often found imbedded in rocks having a compact base. To such rocks the name of porphyry is given, and by analogy a rock with a granular base enclosing distinct crystals is designated as porphyritic or porphyroid. Amorphous or vitreous rocks, as pitchstones, are in like manner sometimes porphyritic. The name of porphyry, at first given to a peculiar type of feldspathic rocks, has now become so extended that it is to be regarded as only indicating an accident of structure. The title of amygdaloid is given to various rocks having rounded cavities which are wholly or partially filled with various crystalline minerals. The base of these rocks is generally granular or crypto-crystalline, but is sometimes amorphous, resembling a scoria or vesicular lava, the cavities of which have been filled by infiltration. Such is doubtless the origin of some amygdaloids. In more cases however these cavities have probably been formed like those often found in dolomites and some other rocks, by a contraction during solidification. Porphyroid rocks, in which quartz, orthoclase and other minerals are arranged in orbicular masses, are also sometimes designated amygdaloids, and may be confounded with the two previous classes in which the imbedded minerals are the result of subsequent infiltration. Allied in structure and origin to the last are what are named variolites or variolitic rocks. (See *Geology of Canada*, pp. 606, 607.)

The masses into which some aluminous minerals enter as a prominent element constitute by far the greater part of the rocks now under consideration. These are naturally divided into two classes, whose origin we have pointed out in a recent paper already referred to. (*This Journal*, [2], xxxvi, 218.) The first of these is characterized by containing an excess of silica, with a portion of alumina, much potash, and small portions only of lime, magnesia and oxyd of iron. The second class contains a smaller amount of silica, and larger proportions of alumina, lime, magnesia and oxyd of iron, with soda, and but little potash. These chemical differences are made apparent in the more coarsely crystalline rocks, by the nature of the constituent minerals; and in the compact varieties by differences in color, specific gravity and hardness. Thus in the rocks of the first class the predominant mineral is orthoclase, generally associated with quartz, and the composite rocks of this class seldom have a density much above that of these species; or from 2·6 to 2·7. In the second class, the characteristic mineral is a triclinic feldspar, with pyrox-

ene or hornblende, the feldspar sometimes predominant; while in other cases the pyroxene or hornblende makes up the principal part of the rock. The presence of these latter minerals generally gives to the fine grained rocks of this class a dark color, a hardness somewhat inferior to the more siliceous class, and a density which may vary from 2·7 to more than 3·0. It will however be found that the line between the two classes cannot always be distinctly drawn, inasmuch as rocks containing orthoclase and quartz often include triclinic feldspars such as albite and oligoclase, and by an admixture of hornblende offer a transition to rocks of the second class. On the other hand, quartz is sometimes found with triclinic feldspars and hornblende in the rocks of the second class. Besides these two feldspathic classes, there is a third small but interesting group, in which an aluminous silicate of high specific gravity, such as garnet, epidote, or zoisite replaces the feldspar wholly or in part. These minerals being basic silicates rich in alumina, the relations of this group are naturally with those of the second class, although varieties of these species are found in rocks which belong to the first class.

The silico-aluminous crystalline rocks may thus be conveniently divided into three families. The first of these includes those rocks in which the aluminous mineral is orthoclase, (orthose) from which they may be conveniently designated by the name of the *orthosite* family. The second includes those in which the aluminous element is an anorthic or triclinic feldspar, and may be designated as the *anorthosite* family; chemically related to this are those rocks holding as one of their elements nepheline, leucite, or scapolite. The third family includes those rocks which contain an aluminous silicate of high density, as epidote, zoisite, garnet, andalusite, or kyanite, in place of a feldspathide. Iolite or dichroite, which enters into the composition of some orthosite rocks, appears from its atomic volume to be related to the feldspars, and should take its place along side of anorthite and scapolite as a magnesian feldspathide, while beryl in like manner appears to be a glucinic feldspathide.

It is worthy of notice that some feldspars having the crystallization and density of orthoclase, nevertheless contain large proportions of soda. The loxoclase of Breithaupt appears from the analysis of Smith and Brush to be a true soda-orthoclase; (*this Journal*, [2], xvi, 43,) while the sanidine or glassy feldspar of many trachytes contains potash and soda in nearly equal proportions. The name of potash-albite has been given to some feldspars of this composition, but the trachytic rocks hereafter to be described contain feldspars, which without being glassy, have the composition of sanidine, together with a cleavage and specific gravity which show them to belong to orthoclase rather than to albite. The anorthic feldspars offer in their composition such

gradations from albite to anorthite that the various intermediate species which have been distinguished seem to pass into each other. (*This Journal*, [2], xviii, 270. *Phil. Mag.* [4], ix, 262.)

Next to the feldspars in lithological importance are the two species, pyroxene and hornblende. These are sometimes found associated in the same rock, and the varieties of pyroxene known as diallage and smaragdite are frequently surrounded or penetrated by hornblende. This association of the two species should be kept in mind, inasmuch as the substitution of pyroxene for hornblende in anorthosites, has been made the basis of a subdivision in classification. (*This Journal*, [2], xxvii, 339.) Among the micas found in silicated rocks, besides muscovite and a magnesian mica (phlogopite or biotite), are to be included the hydrated micas observed by Haughton in many of the Irish granites. Of these the one is margarodite, and the other a uniaxial black mica, also hydrated, which he has referred to lepidomelane; (*Trans. Royal Irish Acad.*, xxiii, 593.) The presence of from four to six hundredths of water in the micas of these granites is important in connection with the evidence already given of the intervention of water in the formation of granitic rocks. These two hydrous micas were often found by Haughton to be united in the same crystal; and Rose has remarked a similar association of potash-mica and magnesian mica in certain granites (*Senft, die Felsarten*, p. 206.)

A scientific nomenclature for compound rocks presents such great difficulties that we must be content for the most part with trivial names which have been from time to time imposed. In the case of simple rocks the terms quartzite, pyroxenite, anorthosite, and orthoclasite are sufficiently definite, or they may be further characterized as normal orthoclasite, etc.; while quartzose, micaceous, and quartzo-micaceo-hornblendic orthoclasite would designate various compound rocks of which orthoclase is the base. Such names, however descriptive, will never replace the older terms granite, syenite, etc., which are employed to designate certain forms of orthosite rocks. The frequent association of a triclinic feldspar (oligoclase) with orthoclase in granite rocks, and the partial or total replacement of the micas generally present in these, by hornblende, by chlorite, or by talc; giving rise in the latter case to what is called protogine, are well known. Nepheline (elæolite), natrolite, iolite, and magnetite are sometimes found as elements in granitic, gneissic and syenitic rocks. The name of miascite is given to a granitic mixture of orthoclase and black mica with elæolite, sometimes with hornblende, albite, and quartz.

The structure of these orthosite rocks gives rise also to a great variety of names; thus to coarsely lamellar granites the name of pegmatite is sometimes given, while fine grained mixtures of

orthoclase and quartz have received the names of granulite, leptinite and eurite, or, when apparently homogeneous and crypto-crystalline, petrosilex. These latter forms often become porphyritic from the presence of crystals of orthoclase, giving rise to orthoclase-porphyry, or orthophyre. In some of these porphyries, as in those of Grenville to be described in the third part of this paper, quartz is also present in distinct grains or crystals; while in some of the red antique porphyries the feldspathic base contains no excess of silica, and occasionally encloses crystals of oligoclase or of hornblende. In many cases the granites, syenites, orthophyres, and other orthosite rocks just mentioned are intrusive, while in other instances rocks lithologically indistinguishable from these are indigenous, and becoming schistose pass into gneiss and mica-shist.

The rocks to which the name of trachyte has been given are generally composed in great part of orthoclase, (sanidine). The typical varieties of these rocks are white or of pale colors, granular or finely crystalline, and frequently porous or cellular. They appear to consist of grains, crystals or lamellæ of orthoclase, aggregated without any cementing medium, and to this seems to be due that roughness to which the rock owes its name. Oligoclase, quartz, hornblende and mica are also met with in this rock, which becoming coarsely granular, passes into granite. Such is the case with the trachytes of the Sierra of Carthagena in Spain, described by Fournet as passing from a dull rough grayish feldspathic mass, into a highly crystalline aggregate of feldspar and mica, with or without hyaline quartz, enclosing hornblende, red garnet, and fine blue iolite (*Comptes Rendus*, xliv, p. 1834.)

The trachytic texture is not confined to orthosite rocks. Abich has described under the name of trachy-dolerites a group of trachytoid anorthosites, (dolerites). The cone of the Soufrière of Guadalope is described by Deville as a rough granular rock having the external characters of trachyte, from which it is distinguished by its somewhat greater density, (2·75). It consists essentially of labradorite, with a little quartz, pyroxene, olivine, and magnetite. (*Bul. Soc. Geol. de France*, [2], viii, 425.) Humboldt designates the trachy-dolerites of Etna and of the peak of Teneriffe as trachytes, (*Comptes Rendus*, xliv, 1067); so that this word, like porphyry, comes to indicate nothing more than a peculiarity of structure, which may be assumed by various feldspathic rocks. The trachytic orthosites, as we have seen, pass into granites, from which they do not differ in chemical composition; and their differences in texture probably depend upon the fact that the one was solidified under great pressure, and the other near the surface, trachytes passing in fact into lavas. The observations of Sorby on the fluid-cavities in the crystals of granite and trachyte are in point.

Among the intrusive rocks of Canada, to be described, are granitoid, compact, and earthy varieties of trachytic orthosites, besides trachytic porphyries. These rocks often contain disseminated earthy carbonates, sometimes in considerable amount; as Deville had already shown for some of the trachytes of Hungary, and as I have also observed for those of the Siebengebirge on the Rhine. Trachytes also hold in some cases disseminated portions of a zeolite, apparently natrolite, and through this mixture pass into phonolites, of which a characteristic variety will be noticed in this paper. Obsidian and pumice-stone, which are often associated with orthoclase trachytes, are related to them in composition; and pitchstone and perlite are similar rocks, differing however in containing some combined water. Rocks resembling pitchstone, and sometimes porphyritic from the presence of distinct crystals of feldspar, occur in the south side of Michipicoten Island, Lake Superior, but have not yet been examined. Analyses by Jackson and by Whitney of the pitchstones of Isle Royale will be found in this Journal, [2], xi, 401 and xvii, 128.

The presence of anorthic feldspar, generally oligoclase, in many granites and trachytes, not less than the admixture of orthoclase crystals in some of the trachytic-dolerites of Etna, serves to connect the orthosite with the anorthosite family. Great masses of indigenous rock in the Labrador series in Canada, are made up of almost pure granular labradorite, or related triclinic feldspars, and might be termed normal anorthosites, (*this Journal*, [2], xxxvi, 224; *Geol. of Canada*, 588). In most cases, however, these feldspars are intermingled with some other mineral, commonly hornblende or pyroxene.

The name of diorite is by good authorites restricted to rocks whose predominant elements are triclinic feldspars with hornblende, while the names of diabase and dolerite distinguish those rocks in which pyroxene takes the place of hornblende. In some anorthosite rocks however, pyroxene and hornblende are intimately associated, so that a passage is established from diorite to diabase. The feldspar of diorites varies in composition from albite to anorthite, and is occasionally accompanied by quartz. This, though most frequent with the more siliceous feldspars, is sometimes met with in diorites which contain feldspars approaching to anorthite in composition. Sometimes the two constituent minerals are distinct and well crystallized, constituting a granitoid rock: fine examples of this, hereafter to be described, occur in the intrusive hills of Yamaska and Mount Johnson. At other times the diorite is finely granular or compact, when its color is generally of a green more or less dark from the disseminated hornblende, and it takes the name of greenstone. The greenstones of the Huronian series are in part at least diorites,

and probably indigenous, but a great number of the so-called greenstone-traps are pyroxenic, and belong to the class of diabase or dolerite. Diorite not unfrequently contains a mica, which is generally brown or black in color. Chlorite, magnetite, ilmenite and sphene often occur as disseminated minerals, as also carbonates of lime, magnesia and oxyd of iron. The finer grained diorites are frequently porphyritic from the presence of crystals of feldspar or of hornblende. Occasionally this rock is concretionary in its structure, as in the obicular diorite or napoleonite of Corsica; which contains a feldspar allied to anorthite, with hornblende, and some quartz. The norite from Sweden is a granular mixture of a similar kind, containing also mica; and the ophite of some writers is a diorite in which hornblende greatly predominates.

The rocks which are essentially composed of anorthic feldspar and pyroxene, present still greater diversities than the diorites, and have received various names based upon differences in texture and in the form of the pyroxenic element. It is here proposed to restrict the name of dolerite to such of these rocks as contain the black augitic variety of pyroxene, and to include the mixtures of triclinic feldspars with all the other varieties of this species under the head of diabase. The finer grained and impalpable varieties of diabase have received the name of aphanite, which is often indistinguishable from the corresponding forms of diorite, and like these may become porphyritic, giving rise to the augite-porphyry of some authors. Different varieties of this porphyry have received the name of labradophyre, oligophyre, and albitophyre, according to the composition of the imbedded feldspar crystals. These are sometimes accompanied by crystals of augite, or are altogether replaced by them.

The name of hyperite or hypersthenite has been given to those varieties of diabase which contain hypersthene or diallage. These rocks occur abundantly in the Labrador series, where the hypersthene in them sometimes takes the form of a green diallage, or passes into a finely granular pyroxene, and is associated with red garnet, ilmenite, and a little brown mica; in addition to which epidote is said to occur in the hyperites of the same series in New York, and olivine is mentioned as being found in the hyperites of Sweden, and of the Island of Skye. Hornblende is also in some localities associated with the hypersthene. The hyperites, although indigenous rocks in the Labrador series in Canada, are described as forming in other regions intrusive masses.

Those varieties of diabase or hyperite which contain diallage have, by the Italian lithologists been called granitone, but by Rose and others have been described under the name of gabbro. This rock sometimes contains hornblende, mica, and an admix-

ture of epidote. A compact white or greenish-white epidote, or zoisite, which has the hardness of quartz and a density of 3·3, to 3·4, is the mineral named saussurite. This with smaragdite, which is an emerald-green pyroxene, often mingled with hornblende, and passing into diallage, forms the euphotide of Hauy. Compact varieties of labradorite and of other triclinic feldspars have by most of the modern lithologists been confounded with saussurite, and hence the name of euphotide is frequently given to the so-called granitone or gabbro, which is only a diallagic variety of diabase. The true euphotide often contains a portion of talc, and sometimes encloses crystals of a triclinic feldspar, apparently labradorite, thus offering a transition to diabase. See farther my researches on Euphotide and Saussurite (*this Journal*, [2], xxvii, 339, and xxxvii, 426.)

Under the name of dolerite, as already remarked, it is proposed to class such anorthosite rocks as contain a black ferruginous pyroxene or augite. These rocks, which are sometimes coarsely granular or granitoid in their structure, pass into fine grained or compact varieties, which are distinguished by the names of anamesite and basalt. To these latter varieties belong a great part of the greenstone-traps, although in rocks of this texture it is often impossible to determine whether it is hornblende or pyroxene which is mingled with the feldspar. Olivine in grains or crystals frequently occurs both in the fine grained basaltic dolerites and in the granitoid varieties, giving rise by its predominance to what is called peridotite. Some fine grained dolerites are porphyritic from the presence of black cleavable augite crystals, forming an augite-porphyry. Finely disseminated carbonates of lime and oxyd of iron are occasionally present in these rocks to the extent of twenty per cent, and even more. In like manner, magnetite and ilmenite, which are often associated, may constitute several hundredths of the mass. Many fine grained greenstones contain, like phonolite, large portions of some zeolitic mineral, and they often abound in chlorite. The pyroxene in these rocks is sometimes replaced by a highly basic silicate. Some varieties of what has been called diallage may be represented as an aluminiferous pyroxene *plus* a hydrate of magnesia. At other times a mineral approaching in composition to a ferruginous chlorite (frequently amorphous) enters into the composition of these anorthosites, and even in some cases appears to replace altogether the pyroxene or hornblende, constituting an aberrant form of diorite or of diabase, which is not uncommon among greenstones, and for which a distinctive name is needed. See on this point *Geology of Canada*, pp. 469, 605, and the remarks on melaphyre below.

The finer grained dolerites are often cellular, giving rise to amygdaloids, whose cavities are generally filled with calcite,

quartz, or some zeolitic minerals. To these amygdaloids the name of spilite is sometimes given. Earthy varieties of basalt, which are frequently the result of partial decomposition, constitute the wacke of some writers. It is doubtful how far many of these spilites and wackes have a claim to be considered as crystalline rocks, inasmuch as they appear in very many cases to be nothing more than aqueous sediments accumulated under ordinary conditions, or perhaps in some cases derived from volcanic ash or volcanic mud. As the other extreme of this series of rocks we may notice that dolerites often assume a trachytic form —the trachy-dolerites already mentioned—or constitute the lavas from modern volcanos.

Among the compound rocks which are related to the preceding group by the presence of augite may be noticed nepheline-dolerite, in which nepheline replaces the feldspar; and analcimite, a variety into which analcime enters in large amount. Scapolite also in some cases replaces feldspar, and forms with green pyroxene, a peculiar aggregate associated with the Laurentian limestones. Leucite enters as an important element in some dolerites, and even replaces wholly the feldspathic element, giving rise to what has been called leucitophyre or leucilite.

[Leucite is generally regarded as an exclusively volcanic mineral, but according to Fournet, it occurs like other feldspars in mineral veins, forming the gangue of certain auriferous veins in Mexico, (*Géologie Lyonnaise*, p. 261). According to Scheerer leucite also occurs in drusy cavities with zeolites and quartz at Arendal in Norway; although it would seem to be rare in this locality since Durocher was not able to detect it, (*Annales des Mines*, [4], i, 218). The conditions required for the formation of this feldspathide must be peculiar, since the volcanic rocks which afford it are confined to a few localities; and since while it contains a large amount of potash it is a basic silicate, and found among highly basic rocks, in which potash compounds are generally present only in very small quantities. The agalmatolite rocks, including dysyntribite and parophite, (*Geology of Canada*, p. 484,) are however basic aluminous silicates in which potash predominates, and might be supposed under certain conditions of metamorphism to yield leucitic rocks.]

The name of melaphyre, which is employed by many writers on lithology requires a notice in this connection. It was proposed by Brongniart as a synonym for black porphyry, (melaporphyre,) and defined by him in 1827 as a porphyry holding crystals of feldspar in a base "of black petrosiliceous hornblende." (*Classif. des Roches*, p. 106.) Subsequent researches showed that some of these porphyries were really augitic; and Von Buch employed the name of melaphyre as synonymous with augite-porphyry, in which he was followed by D'Halloy,

(*Des Roches*, p. 75). In consequence of this confusion, and of the vague manner in which the term is used to include rocks which are sometimes diorites and sometimes varieties of dolerite or basalt, Cotta seems disposed to reject the name of melaphyre as a useless synonym, in which I agree with him. (*Gesteinslehre*, p. 48.) More recently however, Senft (*Die Felsarten*, p. 263,) has endeavored to give a new signification to the term, and defines melaphyre as a reddish-gray or greenish-brown colored rock, passing into black, and containing neither hornblende nor pyroxene. The melaphyres of Thuringia and of the Hartz, according to him, consist of labradorite with iron-chlorite, (delessite,) carbonates of iron and lime, and a considerable portion of titaniferous magnetic iron. Hornblende and mica are present only as rare and accidental minerals. We have already alluded to this class of anorthosite rocks, as requiring a distinctive name, but from the historical relations of the word melaphyre, it seems to be an unfortunate appellation for rocks which are not black in color, and from which both hornblende and pyroxene are absent.

We now come to consider that third group of silicated rocks, in which the feldspathides are replaced by the denser double silicates of the grenatide family, garnet, epidote, zoisite, and perhaps idocrase. Red garnet enters into many gneissic rocks, and even forms with a little admixture of quartz, rock masses. In some of these, as in the Laurentian series, there appears an admixture of pyroxene, forming a passage into omphazite or eclogite; which consists of smaragdite (pyroxene) and red garnet, sometimes mixed with mica, quartz and kyanite, and passes through an increase of the latter into disthenite or kyanite rock. An aggregate of hornblende and red garnet forms a bed in the Green Mountains, and an admixture of red garnet with lievrite and a little mica makes up a rock in the Laurentian series. This is evidently related to eulysite, a rock forming strata in gneiss in Sweden, and consisting of garnet, pyroxene, and a mineral having the composition of an olivine in which the greater part of the magnesia is replaced by ferrous and manganous oxyds. Related to this is an apparently undescribed rock from the Tyrol, of which a specimen is before me, consisting of red garnet, green pyroxene and yellowish-green olivine, the latter greatly predominating; and also a coarsely crystalline rock from Central France, recently described by the name of cameleonite, and composed of olivine, with pyroxene, and enstatite, a magnesian augite; these minerals being accompanied by spinel, sphene and ilmenite. I have already alluded to the true euphotides, in which a compact zoisite, (jade or saussurite,) takes the place of feldspar in a rock the other element of which is pyroxene, and have shown how the occasional presence of a triclinic feldspar connects euphotide with diabase. (*This Journal*, [2], xxvii, 336.) In

the same paper are described rocks made up of a white compact garnet, with and without hornblende and feldspar, and also an epidosite, composed of epidote and quartz.

By the disappearance of the aluminous silicate from the rocks of the second and third groups, a passage is established to the amphibolites and pyroxenites, and these, through diallage rock, offer a transition to the ophiolites or serpentines. These relations are well exhibited in Eastern Canada, where the diorites or greenstones, which are sometimes highly feldspathic, pass into actinolite rock and hornblende slate on the one hand, and into diallagic diabase and diallagic ophiolite on the other.

These greenstones, which contain a chloritic mineral, and are often epidotic, pass gradually into compact or schistose chloritic rocks, frequently enclosing nodules or layers of epidote, either pure or mingled with quartz. The relations between these various rocks are such that after a prolonged study of them I find it difficult to resist the conclusion that the whole series, from diorites, diallages and serpentines, to chlorites, epidosites and steatites has been formed under similar conditions, and that they are all indigenous rocks. (*Geology of Canada*, pp. 606, 612, 652.) I have elsewhere expressed the opinion that these silicates are probably of chemical origin, and have been deposited from solutions at the earth's surface. The sepiolite or hydrous silicate of magnesia, which occurs in beds in tertiary rocks, the neolite of Scheerer, the silicates of lime, magnesia and iron-oxyd deposited during the evaporation of many natural waters; and the silicates of alumina like halloysite, allophane and collyrite, and that deposited by the thermal waters of Plombières, all show the formation and deposition at the earth's surface of silicates, whose subsequent alteration has probably given rise to many minerals and rocks. (*This Journal*, [2], xxxii, 286; and *Geology of Canada*, pp. 559, 577, 581). At the same time the phenomena of local metamorphism furnish evidences that similar compounds have resulted from the action of heat upon mechanical mixtures in sedimentary deposits, (*ibid.* p. 581). A further consideration of this subject, and of the two-fold origin of many siliceous minerals is reserved for another place.

[To be continued.]

SCIENTIFIC INTELLIGENCE.

I. PHYSICS.

1. *On the passage of radiant heat through polished, rough, and smoked rock-salt, and on the diffusion of rays of heat.*—H. KNOBLAUCH has contributed a very elaborate and valuable investigation of the transmission of radiant heat through rock-salt. We give the results in the author's own words, referring the reader for details of apparatus and methods to the original memoir.

I. (1.) Clear chemically pure rock-salt permits rays of heat of all kinds to pass through it in equal proportion, whether the difference between the rays depends upon the fact

a. that they are diffusely reflected from different bodies, or

b. transmitted through different diathermanous bodies, or

c. radiated from different sources of heat.

(2.) In the case of this absorption, equally exercised upon all elementary rays, it is proved that in the solar spectrum of a rock-salt prism the maximum of heat falls in the dark space beyond the red; within the visible portion of the spectrum the distribution of heat is the same in the case of prisms of rock-salt and flint glass.

II. (1.) The heat rays of the sun pass through rough as well as cloudy rock-salt in a less proportion than those of an Argand lamp, and these last, as a rule, in a less proportion than the rays of a source of heat at 100° C.

An increase of roughness diminishes the transmission of every kind of heat but affects solar heat most, that of a lamp less, and that of a dark source least of all.

(2.) Independently of the elective absorption exerted by the substance, the rough surface of unpolished glasses exercises an influence corresponding to that of the internal cloudiness in milky glasses.

(3.) These phenomena can not be referred (with Forbes) to an absorption which affects qualitatively different rays of heat unequally, nor (with Melloni) to an unequal dispersion in the rough and cloudy media depending on the heat-color, by which the rays are more or less deviated from the thermoscope. Neither is the roughness of the surface in itself, nor the direction of the rays proceeding from a single point the determining condition.

(4.) The diffuse heat arising from radiation through rough or cloudy screens or reflection from rough surfaces radiates more abundantly through diffusing screens according as (*a*) the rays are more diffuse, (*b*) in comparison with parallel rays, as the screens are more diffusive.

(5.) In fact the really determining condition of the passage through these screens is whether the incident rays are parallel, or more or less variously radiated from a greater or less number of points.

(6.) Hence, for one and the same source of heat, the ratio of transmission in question (in spite of a constant quantity of heat falling directly upon the plates) diminishes with the distance of the source, and the more rapidly the more diffusive the screen.

(7.) It is possible, by a proper arrangement of the experiments, to cause the more abundant passage of rays of heat from a source at 100° C. in comparison with those from the lamp, cited in (1.), to disap-

pear, and even, conversely, to bring about a more abundant transmission of the heat of the lamp.

III. (1.) In the passage of radiant heat through rock-salt covered with soot an elective absorption (suspected by Melloni) takes place without diffusion. A diffusive action (supposed by Forbes) never takes place in consequence of the rough surface of the layer of soot, but sometimes in consequence of a tarnishing of the rock-salt plate in the process of covering with soot.

(2.) In the case of transmission through thin layers of metal laid upon glass the first process takes place without the last.

(3.) The presence of an elective absorption exerted during transmission is most certainly recognized by determining whether the heat before and after its passage through the substance in question retains unchanged or varies its capacity to pass through other (clear) diathermanous bodies with a smooth surface.

(4.) A diffusive action is best tested by either of the following methods.

a. If solar heat be allowed to pass through the screen in question, and the transmitted be compared with the direct rays, either both groups of rays exhibit an equal power of transmission through colorless rock-salt, or else the first passes more freely than the second group. In this last case the plate investigated is diffusive.

b. When, of two groups of rays of the same thermic color, one of which consists of parallel and the other of diffusive rays, the latter passes most easily through the substance tested, this substance is diffusive. In this process a method is pointed out for the comparison with each other of different degrees of diffusion within very wide limits.

IV. (1.) *a.* By diminishing the angle which the rays of heat form with an unpolished or cloudy plate the diffusion exerted upon them is in general increased. This increase, with the change in inclination, in the first place becomes larger with the generally diffusive property of the screen, but then again grows less to such a degree that in very rough and sufficiently cloudy plates, just as in the case of clear ones no difference can be detected in the behavior of rays which are transmitted at different angles of inclination.

b. A diffusion produced by reflection from rough surfaces diminishes, on the contrary, for the more obliquely incident rays, and passes finally into regular reflection.

(2.) Between the smooth and the two-sided rough surface there are circumstances, in consequence of which, independently of every process in the interior of the substance, the simple mechanical quality of the surface produces a "coloration" of the transmitted heat.

(3.) It follows, therefore, that in the case of the rough and cloudy media in question, a distinction must be made between the action of the diffusion, which is always present, and that of the elective absorption which sometimes occurs.

(4.) Fused common salt produced a diffusion but no heat-coloration.

(5.) Another piece of rock-salt was found to be chemically and mechanically impure, and exercised both a diffusive action and an elective absorption. Circumstances of this kind explain the varying observations made in different experiments with rock-salt.—*Pogg. Ann.*, cxx, 177.

W. G.

II. CHEMISTRY.

1. *On a cyanid of phosphorus.*—HÜBNER and WEHRHAUE have described a tercyanid of phosphorus obtained by the following process. Perfectly dry cyanid of silver is heated in a glass tube with an equivalent quantity of terchlorid of phosphorus diluted with chloroform. The double decomposition requires a temperature of 120° C. to 140° C. for several hours. The chloroform is distilled off in a current of carbonic acid gas and the cyanid of phosphorus sublimed into the neck of the retort. Tercyanid of phosphorus forms long brilliant snow-white crystals. When gently heated they take fire in the air and burn with a bright light. Water decomposes the cyanid with violence, forming phosphorous and cyanhydric acids. The crystals melt and volatilize at about 190° C. Analysis proved that the constitution of the cyanid of phosphorus is PCy_3; the authors propose to study the products of its decomposition.—*Ann. der Chemie und Pharm.*, cxxviii, 254, Nov. 1863. W. G.

2. *On Indium.*—REICH and RICHTER have given some further details of the new metallic element, Indium, discovered by them in the Freiburg blendes. Indium gives in the spectroscope two blue lines, of which the brighter stands at 98, the fainter at 135, of a scale on which the sodium line stands at 38, and the blue strontium line at 93. A compound of indium colors the flame of Bunsen's burner violet, so that the presence of the metal may be detected without the spectroscope. The metal as obtained by reducing the oxyd before the blowpipe on charcoal with soda is soft and ductile, leaving on paper a streak which is brighter than that of lead and somewhat like that of tin. The metal dissolves in chlorhydric acid with evolution of gas, and the solution gives the blue line with great intensity. The hydrated oxyd precipitated by ammonia is white and shiny: tartaric acid prevents its precipitation by ammonia, but sulphid of ammonium produces in this solution a voluminous white precipitate. Potash behaves like ammonia; carbonate of soda precipitates a white crystalline carbonate. The oxyd ignited in a current of hydrogen gave no water and remained unchanged. Heated with carbon in a current of chlorine the oxyd yields a very volatile chlorid condensing in colorless crystalline leaves with the lustre of mother of pearl. This chlorid deliquesces readily, and on drying is partially decomposed. The chlorid gives the blue line in the spectroscope with great intensity, but in this case the duration of the line is very short. It is better to heat the oxyd in a platinum spoon with a little chlorhydric acid, when the blue line is rather less brilliant but lasts longer. A solution of the metal in chlorhydric acid gives with ammonia and sulphid of ammonium a grayish brown precipitate, but it is possible that the color may arise from impurities. The separation of iron from indium is difficult. The chlorid gave with ferrocyanid of potassium a white precipitate, with a shade of blue from the presence of iron, ferridcyanid gave no precipitate, sulphocyanid of potassium a pale red, owing to the presence of iron. The oxyd gives no blue color before the blowpipe with cobalt solution, and after ignition dissolves slowly but completely in chlorhydric acid. The authors satisfied themselves that indium occurs only in the Freiberg zincblende, and not in the arsenkies and schwefelkies.—*Journ. für prakt. Chemie*, Band 90, 172. W. G.

III. MINERALOGY AND GEOLOGY.

1. *Eusynchite and Dechenite.*—In an extended investigation on Vanadium, C. Czudnowicz reviews the analyses of *vanadinite*, *dechenite*, *arœoxene* and *eusynchite*. He shows, that the method used by *Tschermak* for the indirect determination of vanadic acid, in the *rhombic vanadinite* from Kappel in Carinthia, is incorrect, and the conclusion that the mineral was a simple vanadate of lead, $\dot{P}b\dot{V}$, is an assumption not justified by the facts: the only datum for this, being a single determination of the per-centage of lead. Czudnowicz gives the following new analyses of *eusynchite:*

	Ṗb	Żn	V̈*	S̈i	Ṗ		
1.	56·47	16·78	23·55	3·20	*traces*	=	100
2.	53·91	21·41	19·17	5·51	*traces*	=	100

* By loss.

From these results it appears that eusynchite is a ter-basic vanadate of lead and zinc, with the formula $(\dot{P}b, \dot{Z}n)^3\ddot{V}$. Czudnowicz calls attention to the analogy between *eusynchite*, *arœoxene* and *dechenite*, and suggests that the latter may contain zinc, the presence of which might have been overlooked, as was the case in Nessler's analysis of eusynchite.—(*Pogg. Ann.*, cxx, 17.)

[In a note to Nessler's analysis of eusynchite, published in the 4th Supplement to Dana's Mineralogy (*this Journal*, [2], xxiv, 116, July 1857), I stated that, on qualitative analysis of this mineral, I had found it to contain zinc, and attention was also called to its remarkable resemblance to dechenite. This statement is now confirmed by the analyses of Czudnowicz, although he has overlooked my observations on eusynchite, as also the fact that in the same article I pointed out the existence of zinc in dechenite, and suggested the probability that dechenite and arœoxene were identical. About the time my note was published, Bergemann gave the following analysis of arœoxene in Leonhard and Bronn's *Jahrbuch für Mineralogie* (1857, p. 397):

Ṗb	Żn	Ä̇s	V̈	Ä̇l Ḟe*	
52·55	18·11	10·52	16·81	1·34	= 99·33

* With traces of phosphoric acid.

Bergemann mentions that arœoxene and dechenite occur together at Dahn, in the Palatinate, but that dechenite may be distinguished from arœoxene by the color, the former being a beautiful red, while the latter is reddish-brown to deep brown. In the original analyses of dechenite by Bergemann, he found in the dark red crystalline variety, in two determinations, 52·92 and 53·72 p. c. of oxyd of lead, and in the yellowish variety 50·57 p. c. of oxyd of lead. In some specimens, he obtained on charcoal a reaction for arsenic, although, he says, the pure specimens contained no arsenic. It would seem then, that Bergemann considers arœoxene and dechenite distinct mineral species; he, however, gives us no new examination of dechenite, but merely re-asserts that dechenite is a neutral vanadate of lead. I have examined a specimen of dechenite obtained from Dr. Krantz in 1851, shortly after Krantz and Bergemann had described this species, and have found that it contains, not only *zinc*, but *arsenic*. The specimen has the appearance of being pure and unaltered; it is perfectly homogeneous, has a brownish-red color, is botryoidal

in form, and, under the lens, its structure appears crystalline. There is every probability that this specimen, which Dr. Krantz, the discoverer of the species, called dechenite, has the same composition as aræoxene. It is worthy of note, that the method used by Bergemann for the quantitative determination of vanadic acid, would not separate it from arsenic acid and oxyd of zinc, had such been present. Further, it is suggested by Czudnowicz, that the fact that Bergemann was unable to separate sulphuric acid from the so-called pure vanadic acid by heat, indicated the presence of a base with the vanadic acid, as it is well known, and fully established by the observations of Fritzsche and Schafarik, that there is no difficulty whatever in effecting this separation. It is also a somewhat singular coincidence that dechenite, if it be a neutral vanadate, should happen to have the same percentage of oxyd of lead as the terbasic vanadate aræoxene. It is further somewhat peculiar, if they are distinct species, that their specific gravity should be so nearly identical: dechenite having a density of 5·81, while that of aræoxene is 5·79. The same may be said of their hardness and the other physical characters, except a questionable difference in color. Any one reading v. Kobell's description of aræoxene[1] and Bergemann's original description of the physical characters of dechenite[2] could hardly fail to conclude that they are the same mineral. To all this, adding the fact that Dr. Krantz, the discoverer of dechenite, considers the two minerals to be identical, and further, that a specimen of the so-called pure dechenite, received from Dr. Krantz, as early as 1851, proves to have all the characters of aræoxene, we think we may safely question the accuracy of Bergemann's results in his examination of dechenite. Czudnowicz calls especial attention to the circumstance that all the native vanadates thus far described, of which we have trustworthy analyses, are basic in their character.—G. J. B.]

2. *Göthite from Lake Superior.*—This mineral is found associated with hematite at the Jackson Iron Mountain, near Marquette, Lake Superior. Some of the specimens have the hyacinth red color which characterizes the variety of göthite called by the Germans "Rubinglimmer." It also occurs in acicular crystals of an almost velvet-black color and lustre, and it is occasionally found in distinct trimetric crystals. A determination of the water gave 10·47 p. c. G. J. B.

3. *Szaibelyite.*—This new borate, described by Peters and already noticed briefly in this Journal,[3] has been further investigated by Stromeyer and Peters.[4] It occurs disseminated through a gray granular limestone at Werksthal near Retzbanya. This limestone, treated with dilute nitric acid in the cold, gave a residue consisting of a crystalline powder, and also rounded kernels of the size of a lentil. These kernels are translucent, white on the exterior, and interiorly yellowish. Hardness, between 3 and 4. Stromeyer found the limestone to contain 16·6 of crystalline needles, and 14·8 of the rounded kernels. The specific gravity of the former was 2·7, of the latter 3·0. The air-dried mineral was constant in weight at 100° C. Analysis of the two varieties gave:

	B̈	Mg	Fe	Ḣ	Cl	Quartz.	
1. Needles,	36·66	52·49	1·66	6·99	0·49	0·20	= 98·49
2. Kernels,	34·60	49·44	3·20	12·37	0·20	——	= 99·81

[1] Jour. prakt. Chem., l, 496.
[2] Vol. xxxiv, p. 221.
[3] Pogg. Ann., lxxx, 393.
[4] Ber. Wien. Akad., xlvii, 348.

The needles contained traces of carbon, and oxyd of manganese. If the chlorine is considered to exist as MgCl and the iron as $\dot{F}e^2\ddot{H}^3$, and these with the 0·20 quartz be subtracted from No. 1, and averaged to 100, the composition of the mineral will be $\ddot{B}$ 38·35, $\dot{M}g$ 54·65, $\ddot{H}$ 7·00=100. This gives the formula $3(\dot{M}g^5\ddot{B}^2)+4HO$. A similar calculation made with No. 2 gives $\ddot{B}$ 36·13, $\dot{M}g$ 51·52, $\ddot{H}$ 12·35=100, and the formula $3(\dot{M}g^5\ddot{B}^2)+8\ddot{H}$, or 4 atoms more of water than the crystalline variety. The composition is related to that of stassfurthite, this last mineral being an acid hydroborate combined with chlorid of magnesium, while szaibelyite is a basic hydro-borate in which chlorid of magnesium is not an essential constituent. [The specific gravity of the borate with 4 atoms of water is stated to be less than that with 8 atoms of water, this is probably either a misprint or an error in observation.—G. J. B.]

4. *Astrophyllite.*—F. Pisani has reëxamined Scheerer's astrophyllite. It is a micaceous substance, found at Brevig imbedded in a feldspar of the zircon-syenite, and is associated with catapleiite, ægirine, and large prisms of a black mica. It forms six-sided prisms, frequently lengthened in the direction of the shorter diagonal, sometimes in stellated groups and having a basic cleavage. In thin leaves translucent. Color bronze-yellow. The powder resembles mosaic gold. Laminæ only slightly elastic. H.=3. G.=3·324. Before the blowpipe swells up, and fuses easily to a black magnetic enamel. With soda and borax shows a strong manganese reaction. In the spectroscope gives the lines of lime, soda, potash, and lithia. Decomposed by chlorhydric acid with separation of silicic acid in scales; the solution heated with zinc or tin gives the reaction for titanic acid. Analysis gave—silica 33·23, titanic acid 7·09, zirconia 4·97, alumina 4·00, ferric oxyd 3·75, ferrous oxyd 23·58, manganous oxyd 9·90, lime 1·13, magnesia 1·27, potash 5·82, soda 2·51, lithia *trace*, ignition 1·86=99·11. The oxygen ratio of the bases to the acid, considering the titanium and zirconium to be sesquioxyds and basic, is as 16·87 to 17·72, which would indicate that this species belonged to the mica group of minerals. The small amount of alumina in the mineral is singular.—*Jour. f. prakt. Chem.*, xc, 53, from *Comptes Rendus*, lvi, 846. G. J. B.

5. *Bragite.*—J. A. Michaelson has analyzed a columbate from Helle in Norway, which he says is the *bragite* of Forbes and Dahl. The mineral is grayish-brown in color, has an uneven fracture and a metallic lustre. H.=4·5. G.=5·40. With salt of phosphorus and borax gives a bead, which is greenish-yellow while warm, and colorless on cooling. Composition:

$\ddot{C}b$	$\dot{Z}r$	$\dot{Y}$	$\dot{C}e$	$\dot{U}$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$	$\dot{P}b$	$\ddot{H}$
48·10	1·45	32·71	7·43	4·95	1·37	0·11	1·82	0·39	0·09	1·03

from which Michaelson draws the formula $\dot{R}\ddot{C}b$, and considers the mineral to be identical with tyrite and fergusonite.—*J. f. pr. Chem.*, xc, 108. [Tyrite and fergusonite need further investigation; it may be that bragite and tyrite are identical, but the analyses of Hartwell, Weber and Forbes would indicate that fergusonite and tyrite are distinct species.—G. J. B.]

6. *On Organic Remains in the Laurentian Rocks of Canada;* (from a letter to the Editors of this Journal from Sir W. E. Logan, F.R.S., dated Montreal, Feb. 17th, 1864.)—In August, 1859, I exhibited to the

American Association at Springfield, Mass., specimens of what was regarded by me as an organic form externally resembling *Stromatocerium*, and found in the Laurentian limestone of the Ottawa. These were described by me in the *Canadian Naturalist* for that year, (vol. iv, p. 300,) and afterwards figured in the *Geology of Canada*, (p. 49). In 1863, similar forms were detected by the Geological Survey, in the serpentine-limestone of Grenville, sections of which we have prepared and submitted for microscopic examination to Dr. J. W. Dawson. He finds that the serpentine, which was supposed to replace the organic form, really fills the interspaces of the calcareous fossil. This exhibits in some parts a well-preserved organic structure, which Dr. Dawson describes as that of a Foraminifer "growing in large sessile patches after the manner of *Carpenteria*, but of much greater dimensions, and presenting minute points which reveal a structure resembling that of other foraminiferous forms, as for example *Calcarina* and *Nummulites*." Figures and descriptions will soon be published by the Geological Survey.

Large portions of the Laurentian limestones appear to be made up of fragments of these organisms, mixed with other fragments which suggest comparisons with crinoids and other calcareous fossils, but cannot be distinctly determined. Some of the limestones are more or less colored by carbonaceous matter, which Dr. Dawson, has found to exhibit under the microscope evidences of organic structure, probably vegetable.

In this connection it may be noticed that Mr. Sterry Hunt, in a paper presented to the Geological Society of London, in 1858, (see also *this Journal*, [2], xxxi, 296,) insisted upon the presence of beds of iron-ore, metallic sulphurets and graphite, in the Laurentian series as "affording evidence of the existence of organic life at the time of the deposition of these old crystalline rocks."

It was stated in the *Geology of Canada*, p. 839, (and also in *this Journal*, [2], xxxvi, 223,) that these oldest known stratified rocks, constituting the great Laurentian system, are probably to be divided into two unconformable groups. Subsequent examinations during the past year have furnished additional evidence that what we have called the Labrador series rests unconformably upon the true Laurentian series. It is the limestones of this latter and more ancient division which have afforded the Foraminifera noticed above.

7. *On Glaciers and other phenomena connected with the Himalayas;* (Proc. Roy. Geog. Soc., Jan. 1864.)—Dr. Falconer, after describing the progress of the Trigonometrical Survey in India, next drew attention to the glacier system of the Himalayas. All the best observers—Dr. Thomson, Jacquemont and others—had been of opinion that there was but one great system of mountains. There was no such thing as any break of mountain-range, or any distinct mountain-chains. There were great rivers which cut them across, rivers like the Indus, the Sutlej, and some feeders of the Ganges; but, regarded in one grand aspect, they constituted a series of mountains with ravines and valleys intervening. Viewed, then, in this light, there were two great ranges which culminated to especially great altitudes, and which bounded the Indus river to the south and to the north; and this being one of the points where the Himalayan chain attained its greatest altitude, there the glacial phenomena were developed in the greatest grandeur and upon the loftiest scale. The paper

referred to that part of the range which bounded the valley of the Indus upon the north, the Kara-Korum, or Mooz-tagh, or the "Icy range of mountains," and the other great series of them were the mountains which bounded the Indus upon the south. Although the glaciers upon the Shigar valley and in the valley of Bialdoh, which he himself had visited in 1838, were of such surpassing grandeur and importance, as had been mentioned by Sir Roderick Murchison, it was but fair to say that upon the northern side there were glaciers which, so far as description went, were equally grand, if not grander. Those to which he should especially refer were the glaciers at the head of the Zanscar river. Mr. J. A. Arrowsmith was well acquainted with the mountain-ridge to which he referred and the glaciers which arose from it. There was a river called the Chenab, and a mountain-range which stretched across between the Indus and the Chenab. The pass of the dividing ridge at this point was 18,000 feet above the level of the sea; and upon either side, but more especially upon the north, at the head of the Zanscar river, were some of the grandest glacier phenomena to be seen in any part of the world. There were glaciers extending from a very great distance, and having enormous width, and which, until the description that had been given by Capt. Austen, had been unrivalled by any glacial phenomena with which they were acquainted, except the glacial formations in the Arctic regions.

With regard to the glaciers upon the north, the Indus ran through a flat country westward, receiving from the north three great branches; the first branch, called Sha-Yuk, from the Kara-Korum, next the Nubra river, and also the Shigar, which was the especial object of Capt. Godwin-Austen's communication. Now, the Shigar valley was the third of importance of all the affluents of the Indus, and was bounded by mountains of great elevation. Some of them which had been measured by Captain Montgomery attained a very great elevation; one a height of 28,000 feet above the level of the sea. This naturally entailed a prodigious amount of condensation of the moisture of the atmosphere, and led to a very heavy fall of snow, the consequence of which was great glacial phenomena. Twenty-seven years ago he had been up to Arindoh, the extreme termination of the western or Basha branch, and from that point he got across upon the other valley by the Scora-là Pass to the glacier of the Bialdoh river, where he saw all the phenomena which had been described by Capt. Godwin-Austen. Having premised this much with regard to special details, there were one or two points which he was desirous to bring before them. One was, What were the peculiar characteristics of the Himalayan mountains, as well as of all tropical mountains, as compared with our European mountains? There was one characteristic of the Himalayan chain so remarkable that he should take the liberty of explaining it. He presumed that most of his audience had visited either the northern or southern side of the Alps; and those who had been in the plains of Italy, along the valley of the Po, were well acquainted with the numerous lakes which jutted out from the Alps into the plain of Italy. Commencing on the west there were the Lago d'Orta, the Lago Maggiore, the Lago di Lugano, the Lago di Como, the Lago d'Iseo, and the Lago di Garda; in fact, wherever a great valley projected itself from the chain of the Alps at right angles to the strike of the chain, there was, with one exception, a great lake. Regarding these lakes in a general way, without

reference to detailed phenomena, they found one thing which was constant about them—"they were invariably narrow, and some forty or fifty miles long, as notably in the case of Maggiore, Como, and Garda." The next remarkable thing about them was that they invariably radiated out at right angles to the strike of the great chain of the Alps. The Alps made a curve from the Pennine round to the Rhetian Alps. They would also observe that those lakes were severally fed by a great river which proceeded from a high ridge of the chain, and which was thrown forward into the plains of the valley of the Po. If they would regard the Himalayan mountains, or any tropical range of mountains whatever, in a similar way, they would find that these phenomena were invariably wanting. Great rivers, like the Indus, the Chenab, the Sutlej and the Ganges, which passed through the Himalayan mountains and debouched into the plains of India, had valleys of infinitely greater importance than the valleys either to the north or south of the Alps; but they were never connected with a lake.

The question then arose, What was the physical reason of this great difference between the tropical mountains and those of temperate Europe? Nearly thirty years ago, he was for ten or twelve years rambling about the Himalayan mountains along a stretch of 800 miles, and he used to open a map before him, and try to make out the comparative features of European and Eastern mountains. He looked to the numerous lakes to the north and south of the Alps; and he would put the map of India alongside, where the same kind of rivers were debouching into the plains, but where there was an utter absence of the lakes; and he used to puzzle himself in trying to discover a physical explanation of this difference. He was perfectly satisfied there must be some secondary conditions which were not common to the two. * * * There was the same kind of elevation above the level of the sea, the same kind of valleys, the same kind of fissures intersecting the valleys.—What then was the explanation? This he would endeavor to indicate. About two years ago, as his friend Sir Roderick Murchison was aware, a paper was brought before the Geological Society of London, by Professor Ramsay, which excited a great deal of attention, and gave rise to a very animated discussion.[1] The theory of the paper was that, as a general rule, lakes in all the temperate and cold regions of the world were the product of glacial excavation; that is to say, that, wherever a glacier came down from a high ridge of mountains into a plain, it ploughed its way down from the solid rocks and carved out a great lake. This was the theory, or rather hypothesis, which Professor Ramsay put forward to explain the lakes which were so abundant in the valleys of the Alps. A similar speculation, but greatly more restricted, had been advanced by Martillet a short time before. He limited the action of the glacier to scouring out the silt of the filled up lake-basins, the origin of which he attributed to antecedent fissures, the result of upheaval. An application of this theory was made to the different physical phenomena which were connected with the case; and it occurred to himself and many others (and he believed Sir Roderick had an opinion in common with himself) that it was not adequate to explain the phenomena; and on the occasion when it was produced, he met it with the most lively opposition in connection with his own experience in the Himalayan mountains. The opposition which he gave to it was

[1] See this Journal, [2], xxxv, 324-345, May, 1863.

upon these grounds. Many of them would remember that the lakes Maggiore and Como were upon the edge of the plains of Italy; that the glaciers—say that of the Ticino, which came down into the Lago Maggiore —came down along a steep incline, and was at last delivered into that lake, which was about fifty miles long, and only eight or nine miles wide at its widest point. Its prolongation nearest to the Mediterranean attained a depth of about 2600 feet below the level of the sea; that is to say, it attained a depth of half a mile below the sea-level. Where the river escaped out of the lake it was not more than 600 feet above the level of the sea. It was a remarkable point in the case that this glacier by the hypothesis should have ploughed its way down and actually dived into the bowels of the earth 2000 feet below the level of the Mediterranean, and then should have again risen up along an incline at a rate of about 180 feet per mile. Without going into all the objections, he might state he believed the principal one was, that the mechanical difficulties in the case were entirely left out of sight by the supporters of that theory; and on that occasion, after very long study of the subject, he endeavored to bring forward what occurred to him as the true explanation of the difference between the Himalayan mountains and the Alps. The difference he believed to consist in this: that, after the last upheaval of the Alps, great fissures, or basins of lakes, were left there, with rivers running into them, in the manner in which the Rhône runs into the lake of Geneva, bringing down enormous quantities of silt, which, if you give a sufficient number of ages, would have completely filled them up. But, before this was accomplished, what is called the glacial epoch commenced; that is to say, there was an enormous projection of ice and snow below the limit that they now saw it in the Alps, out into the plains, both to the north and south of that chain: and, as the snow and ice came down, they filled up those lakes and formed a bridge, upon which the moraine material was carried over, there being a certain measure of incline from the summit of the Alps down to the plains of Italy. When once the basins were filled with ice to the depth of 2500 feet, they made, as it were, a slide or incline, upon which all the solid material could be transported; and that being carried forward by the *vis motrix* of the mass, formed the large moraine which we saw at Lake Maggiore, that of the Brianza, and also the moraine which bounded Lake Garda, where the battle of Solferino was fought. This was the secondary condition that occurred in Europe. Precisely the same primary conditions occurred in the great valleys of the Himalayas, but without the same glacial phenomena. These mountains were thrown up above the level of the sea, and vast perpendicular fissures were left, forming what were at that time the basins of lakes. But in those tropical regions the ice never descended from the highest summits down into the plains of India; and, instead of being filled up by snow, which afterwards melted into water, these lake-basins were gradually silted up by enormous boulders and alluvium of every kind, which were brought down by rivers from the Himalayan mountains. The difference in the two cases was, that, whereas the ice filled up the lake-basins in the Alps, constituting, as it were, the conservative means by which those lakes were saved from being silted up by alluvial and other matters, in the Himalayan mountains this conservative action did not take place, and the lake-basins remaining open were filled up in the man-

ner mentioned. If they would look at the map of the Himalayan mountains, one of the most remarkable things they would observe on the southern side of the chain was, that there were no great lakes whatever —not one that would compare with Lake Lugano, or with any of the second or third-rate lakes in the Alps. But, if they crossed to the northern side of the chain, where the temperature was much colder during the winter, there they would find great lakes. The cold produced the same conservative action on the northern side of the Himalayas, in preventing the lakes being filled up, which it did in the Alps by restricting the silting action.

The next point was one of some interest and importance. There was a material well known in commerce and arts called borax, now largely employed in ceramic products. It used to be got only from India as an export from Thibet, and it was invariably found in connection with hot springs. Within the last twenty years, a remarkable change had taken place. The late Count Larderelle, an original-minded and eminently philanthropic Frenchman, of Leghorn, aware of the presence of boracic acid in the jets of steam which are emitted from the surface of the broken soil in the ravines of Monte Cerboli, on the margin of the Maremma of the Volterra in Tuscany, hit upon the happy idea of utilizing the natural heat in lieu of fuel to effect the process of evaporation. * * * An unbounded supply of boracic acid was the result. As a consequence, the borax of Thibet fell in value from 37*l.* or 40*l.* a ton to nearly half that price, until at length borax was exported from England at the rate of 10*l.* per ton to displace the native article from the bazaars of India. In Thibet the mineral is biborate of soda, which in many places abounds in the soil: while in Italy it is boracic acid. For the best account of the Himalayan region he would refer to Dr. Thomson's 'Travels in Thibet.'

Henry Colebrook, the first who, along with Colonel Crawford, measured the heights of the Dwalagiri, procured from the plateau of Chanthan in the Himalayas, at a height of 17,000 feet above the sea-level, fossil bones, which were brought down and exported as charms into India, to which the natives attributed a supernatural origin, and called them "lightning or thunder bones." At the present time, during eight months of the year, the climate differed in no important respect from that of the Arctic circle, and in the whole of the district there was not a single tree or shrub that grew larger than a little willow about nine inches high. The grasses which grew there were limited in number, and the fodder, in the shape of dicotyledonous plants, was equally scarce. Yet, notwithstanding this scantiness of vegetation, large fossils were found of the rhinoceros, horse, buffalo, antelope, and of several Carnivores—species indicating that, at no very remote period of time, a plateau in the Himalayan mountains, now exceeding three miles above the level of the sea and Arctic in climate, had then such a climate as enabled the rhinoceros and several subtropical forms to exist. It would occupy too much time to explain the details of this complex phenomenon. He would briefly state that the only rational solution which science could suggest was that, within a comparatively modern period, a period closely trenching upon the time when man made his appearance upon the earth, the Himalayas had been elevated 8000 or 10,000 feet.

IV. BOTANY.

1. *Nomenclature.*—Tho propositions for the improvement of zoological nomenclature, made to the British Association at its twelfth meeting, in 1842, by an influential committee, are well known. They were essentially limited to zoology mainly for the reason, which is undoubtedly true, that botanical nomenclature stands in much less need of distinct enactment than zoological. At the recent New Castle meeting the committee on this subject was reconstituted, and instructed "to report on the changes which they may consider it desirable to make, if any, in the rules of nomenclature drawn up at the instance of the association by Mr. Strickland and others, with power to reprint these rules, and to correspond with foreign naturalists and others on the best means of insuring their general adoption." "Accordingly the rules, as originally circulated, are now reprinted [i. e. in the Edinburgh New Philosophical Journal for Oct. 1863, p. 260 et seq.], and zoologists are requested to examine them carefully, and to communicate any suggestions for alteration or improvement, on or before the first of June, 1864, to *Sir William Jardine, Bart., Jardine Hall, by Lockerby, N. B.*"

As most of the propositions are from their nature equally applicable to botany, and as the new committee comprises the names of four botanists, extremely well selected, it is obvious that the improvement of nomenclature of genera and species in natural history in general is contemplated. We feel free, therefore, to make any suggestions that may occur to us from the botanical point of view.

First, we would recommend that "the admirable code proposed in the *Philosophica Botanica* of Linnæus,"—to which, "if zoologists had paid more attention . . . the present attempt at reform would perhaps have been unnecessary,"—be reprinted, with indications of the rules which in the lapse of time have become inoperative, or were from the first over nice: *ex gr.* 222, 224, 225, 227, 228, 229, 230, etc., most of which are recommendations rather than laws. The British Association's Committee has properly divided its code into two parts, 1. Rules for rectifying the present nomenclature: 2. Recommendations for improving the nomenclature in future. The laws all resolve themselves into, or are consequences of the fundamental law of priority, "the only effectual and just one."

Proposing here to comment only upon the few propositions which seem to us open to doubt, we venture to suggest that the "§ 2. *The binomial nomenclature, having originated with Linnæus, the law of priority in respect of that nomenclature, is not to extend to the writings of antecedent authors,*" is perhaps somewhat too broadly stated. The essential thing done by Linnæus in the establishment of the binomial nomenclature was, that he added the specific name to the generic. He also reformed genera and generic names; but he did not pretend to be the inventor or establisher of either, at least in Botany. This merit he assigns to Tournefort, in words which we have already cited in this Journal (vol. xxv, p. 134); and he respected accordingly the genera of Tournefort, Plumier, &c., taking only the liberties which fairly pertained to him as a systematic reformer. While, therefore, it is quite out of question to

supersede established Linnæan names by Tournefortian, we think it only right that Tournefortian genera, adopted as such by Linnæus, should continue to be cited as of Tournefort. So, as did Linnæus, we prefer to write *Jasminum*, Tourn., *Circœa*, Tourn., *Rosmarinus*, Tourn., *Tamarindus*, Tourn., etc. Indeed, it is not fair to Linnæus to father upon him generic names, such as the last two and many more, which Linnæus specially objects to, as not made according to rule. Specific names, of course, cannot antedate Linnæus, even if the descriptive phrase of the elders were of a single and fit word.

"§ 10. *A name should be changed which has before been proposed for some other genus in zoology or botany, or for some other species in the same genus, when still retained for such genus or species.*" The first part of this rule is intended, we presume, to be the equivalent of No. 230 of the *Philosophia Botanica*: "*Nomina generica plantarum, cum zoologorum et Lithologorum nomenclaturis communia, si a Botanicis postea assumta, ad ipsos remittenda sunt.*" We submit that this rule, however proper in its day, is now inapplicable. Endlicher, who in a few cases endeavored to apply it, will probably be the last general writer to change generic names in botany because they are established in zoology. It is quite enough if botanists, and perhaps more than can practically be effected if zoologists, will see that the same generic name is used but once in each respective kingdom of nature.

"§ 12. *A name which has never been clearly defined in some published work should be changed for the earliest name by which the object shall have been so defined.*" Very well. And the good of science demands that unpublished descriptions, and manuscript names in collections, however public, should assert no claim as against properly published names. But suppose the author of the latter well knew of the earlier manuscript or unpublished name, and had met with it in public collections, such name being unobjectionable, may he wilfully disregard it? And as to names without characters, may not the affixing of a name to a sufficient specimen in distributed collections (a common way in botany) more surely identify the genus or species than might a brief published description? Now the remarks of the Committee, prefixed to § 12, while they state the legal rule of priority, do not state, nor in any way intimate, that a wilful disregard of unpublished names, especially of those in public or distributed collections, is injurious, dishonorable, and morally wrong. In the brotherhood of botanists, it should be added, custom and courtesy and scientific convenience in this respect have the practical force of law, the wilful violation of which would not long be tolerated; and the distribution of named specimens, where and as far as they go, is held to be tantamount to publication.

As to the recommendations for the future improvement of nomenclature, in passing under review the "Classes of objectionable names," we wonder that geographical specific names should have been objected to: we find them very convenient in botany and, next to characteristic names, about as good as any. Comparative specific names in *oides* and *inea*, etc., are much used by botanists, and are often particularly characteristic. Specific names derived from persons, used with discretion, and as far as possible restricted to those who have had to do with the species, as dis-

coverer, describer, &c., are surely unobjectionable. Generic names derived from persons are, we agree, best restricted to botany, where, when appropriately applied, they are in good taste, if not too cacophonous. As to closely resembling names, in large genera it may sometimes be best to "call a species *virens* or *virescens*" when there is already a *viridis*. Anagrams, like puns, if not cautiously handled and particularly well made, are intolerable. But what can be prettier, among unmeaning names, than R. Brown's *Tellima?* Botanists will hardly agree that a good generic name which has been effectually superseded by the law of priority, should never afterwards be bestowed upon some other genus of some other order. "It has sometimes been the practice, in subdividing an old genus, to give to the lesser genera so formed the names of their respective typical species." The Committee objects to this usage because the promotion calls for new specific names. To us it seems a natural and proper course, when the name of the species in question is substantive and otherwise fitting,—most proper when (to take a not uncommon case) one used generically in the first place by ante-Linnæan naturalists or herbalists.

But the objection of the Committee is probably connected with a peculiar view which they have adopted as to the way of citing species which have been transferred to some other than the original genus. Here many zoologists, and a few botanists, have been giving themselves much trouble and perplexity, as it seems to us, to little purpose. Take for illustration our Blue Cohosh, originally *Leontice thalictroides* of Linnæus, but afterwards, in Michaux's Flora, taken as the type of a new genus, and therefore appearing as *Caulophyllum thalictroides*. Now if we adopt the view of Linnæus, to which he would probably have adhered had he lived till now, we write the name and the authority thus:—

Leontice thalictroides, Linn.
(Syn. *Caulophyllum thalictroides*, Michx.)

The abbreviated names of the authors appended stand in place of the full reference, e. gr. Linn. Sp. Pl. 1, p. 448, and Michx. Fl. Bor.-Am. 1, p. 205, tab. 21. If the other view be adopted, it stands, in fact:—

Caulophyllum thalictroides, Michx.
(Syn. *Leontice thalictroides*, Linn.)

But, fearful lest the original describer should be robbed of his due credit, it has been proposed to write,—

Caulophyllum thalictroides, Linn. This is not only an anachronism of half a century, but an imposition upon Linnæus of a view which he had not and perhaps would not have adopted. To avoid such fatal objections, it has been proposed to write *Caulophyllum* (Michx.) *thalictroides*, Linn.; which is not only "too lengthy and inconvenient to be used with ease and rapidity," but too cumbrous and uncouth to be used at all. And finally, the Committee propose to write,—

Caulophyllum thalictroides, (Linn.) (sp.),—

which is scarcely shorter, or even to leave out the (sp.) The reader is thus to note that Linnæus originally gave the specific name *thalictroides*, but not the generic. Who did, must be otherwise ascertained. A pretty long experience convinces us that much confusion is risked or trouble expended, and nothing worth while secured by these endeavors to put for-

ward the original rather than the actual application of a specific name. Ante-Linnæan nomenclature broke down in the attempt to combine specific appellation with description. Here the attempt is to connect it with the history of its origin, which, after all, can be rightly told only in the synonymy. The natural remedy for the supposed evil which this mode of citation was to cure is, to consider (as is simply the fact) that the appended authority does not indicate the origin, but only the application at the time being, of the particular name, and so no one is thus robbed of his due. The instructed naturalist very well knows the bibliography of species, or where to look for it; the tyro can learn.

"§ *C. Specific names should always be written with a small initial letter, even when derived from persons or places:*"—on the ground that proper names written with a capital letter are liable to be mistaken for generic. (But no naturalist would be apt to write the name of a species without that of the genus, or its initial, preceding.) Also, "that all species are *equal*, and should therefore be written all *alike*." The question is one of convenience, taste, and usage. As to the first, we do not think a strong case is made out. If mere uniformity be the leading consideration, it might be well to follow the example of the American author who corrected *Ranunculus Flammula* Linn. and *R. Cymbalaria* Pursh, into *R. flammulus* and *R. cymbalarius!* As to taste and usage, we suppose there would be a vast preponderance against the innovation, so far as respects personal names and those substantive names which Linnæus delighted to gather from the old herbalists, &c., and turn to specific use, e. g., *Ranunculus Flammula*, *R. Lingua*, *R. Thora*, *R. Ficaria*, and the like. Adjective names of places and countries, Linnæus printed with a small initial, e. g., *R. lapponicus*, etc. DeCandolle writes such names with a capital letter; and this best accords with English analogy, but has not been universally adopted, and probably will not be.

"§ *F. It is recommended that in subdividing an old genus in future, the names given to the subdivisions should agree in gender with that of the original group.*" The practical objection to this is, that old names should be revived for these genera or subgenera, if there be any applicable ones, which is likely to be the case in botany. A. G.

2. *Annales Musei Botanici Lugduno-Batavi*, edidit F. A. Guil. Miquel. Univ. Rheno-Trajec. Bot. Prof., Musei Bot. L. B. Director. Tom. I, fasc. 1–4, pp. 1–128, tab. 1–4, fol. Amsterdam and Utrecht. 1863. —Professor Miquel, still retaining his chair at the University of Utrecht, has succeeded the late Dr. Blume as Director of the Royal Botanical Museum at Leyden; and that institution, where invaluable materials have been for many years accumulating, already begins to show the effects of his activity and good judgment. Four numbers of the present work, each of eight folio sheets of letter-press and one colored plate, have appeared during the year 1863; and the work is intended to be continued at the rate of five numbers in a year; the price 3 florins each. The extent, character, and importance of this publication may be judged of from the following brief analysis of the contents of the four numbers now before us.

First we have, from the indefatigable Prof. Miquel himself, a revision of the *Araliaceæ* of the Indian Archipelago, with an analytical conspec-

tus of the known genera of the order, and the revision of certain genera, as, for instance, of *Aralia* (from which he again excludes *Panax*). An additional case of identity of peculiar N. E. American with N. E. Asian species, of much interest, is adduced, viz: that the Linnæan *Aralia Chinensis*, *A. Mandschuria* Regel, and the Japanese *A. canescens* Sieb. & Zucc., are all referable to our own familiar *A. spinosa!* Specimens from Georgia, collected by the late Mr. Beyrich, are provisionally named and described as *A. Georgica* Miq., and thus referred to the consideration of American botanists, as to whether it be a distinct species or not. We find in our own collections no indications of a second species allied to *A. spinosa*, nor any specimens with such thin and coarsely toothed leaflets as in ours of *A. Mandschurica*. But the plant is so unmanageable in the herbarium, from the size of the leaves, &c., that a full suite of specimens is hardly to be met with. The view that the Ginseng of Tartary, the Himalayas, and Japan is of the same species as the North American, is adopted.

Secondly, the *Ericaceæ Japonicæ* are elaborated by Prof. Miquel. We are interested to find that a new Japanese true Cranberry is described, also one related to our *Vaccinium erythrocarpon* of the Alleghanies, but with rudimentary dorsal awns to the anthers, thus still more bridging over the difference between *Vaccinium* proper and *Oxycoccus*. Of the latter group, accordingly, Japan would seem to have not only *V. Oxycoccus* and *V. macrocarpon*, which are associated in North America, but even a third species of the same type, and an analogue of our peculiar *V. erythrocarpon*, as well as a species which comes nearer to our Blueberries than any other out of Eastern North America (*V. Smallii* Gray), but still wants the false partitions which characterize ours. More interesting still, *Chiogenes hispidula* turns up in Japan; but thus far only sterile specimens have been gathered. Two Azaleas of the American type are described, with one of which *A. Japonica* Gray, is probably to be identified. *Monotropa uniflora* now appears, as was to be expected, having been detected in the Himalayas.

The *Ericaceæ* of the Indian Archipelago, which follow, are of less interest to us.

Fourthly, *Filices, præsertim Indicæ et Japonicæ*, are described by Professor Mettenius, but thus far only *Gleicheniaceæ* and *Cyatheaceæ*.

Fifthly, the *Equisetaceæ*, by Dr. Milde of Breslau, prefaced by a succinct conspectus of all the known species, only twenty-six in number, arranged according to their affinities, and followed by a particular account of the many varieties of several species.

Sixthly, by Prof. Miquel we have *Ampelideæ Novæ*, with an arrangement of *Vitis* (including *Cissus*, *Ampelopsis*, and *Pterisanthes*), under seven sections, and a critical view of the Indian and Japanese species, with several American. Prof. Miquel confirms the identification of *Vitis Labrusca* of Thunberg (Japan) with our *V. Labrusca*.

Seventhly, *Adnotationes de Cupuliferis*, by the same author. Ninety species of *Quercus* are annotated or enumerated, and two genera propounded, without admitting which it is declared that *Quercus* and *Castanea* cannot be kept apart, viz: *Callæocarpus*, of two Sumatran species, and *Castanopsis* of Don (as a section of *Quercus*), of numerous species variously regarded as Oaks or Chestnuts.

Eighthly, the *Araceæ*, by Dr. Schott, the renowned monographer of the order. A sheet or two of the first part ends the No. 4 of these interesting Annales. A. G.

3. *Martius, Flora Brasiliensis:* fasc. 33–35. July, 1863.—These fasciculi form a volume of no small interest. They comprise the Brazilian *Eriocaulaceæ* by Kœrnicke, the *Gnetaceæ* by Tulasne, the *Cycadaeæ* and *Coniferæ* by Eichler, and the *Ericaceæ* by Meisner.

Of these the *Eriocaulaceæ* only are numerous in species. They here occupy almost 250 pages of letter-press, illustrated by 26 plates. Brazil is the head-quarters of this remarkable tribe, claiming 210 out of the 326 recorded species, and 184 species of its largest genus, *Pœpalanthus;* while of its most cosmopolite genus, *Eriocaulon*, it is second to India. Indeed, the Brazilian empire, with the tropical regions to the north of it up to the Isthmus, contains almost three-quarters of the known species, and members of all of the six genera, except *Lachnocaulon*, of the southern United States. All the *Eriocauloneæ* belong strictly to the eastern side of the American continent; and those of the Old World are almost equally oriental. The only European one, our *Eriocaulon septangulare*, seems as if a waif from North America, and probably was so; while the greater part of that genus is to be found in India and further east, three species reaching westward to Zanzibar and Abyssinia, three to Bourbon and Mauritius, and four to Madagascar. On the western coast of tropical Africa there appear to be five species of *Eriocaulon*, and at the Cape three more, accompanied by a solitary *Pœpalanthus*, an otherwise wholly American genus, with the exception of a single out-of-the-way species at the Isle of Bourbon. The little genus *Mesanthemum*, in character intermediate between *Pœpalanthus* and *Eriocaulon*, consists of three species, one in Brazil, one in Sierra Leone, and one in Madagascar. *Lachnocaulon*, as already noticed, belongs to the Southern Atlantic United States. The two remaining genera, *Tonina*, of a single species, and *Philodice*, of two species, are confined to Brazil and adjacent districts. The Brazilian species appear to have been faithfully elaborated by Kœrnicke, who has also furnished the excellent analyses which enhance the value of the numerous plates.

The Brazilian *Gnetaceæ*, elaborated by Tulasne, comprise 7 species of *Gnetum* and 4 of *Ephedra*. The gymnospermous view is adopted, *Ephedra* being described as having an ovule with a single coat, the apex of which is produced into a styliform tube, *Gnetum* with two coats, the inner prolonged into an exserted tube.

The *Cycadeæ*, contributed by a new collaborator, Dr. Eichler, are merely two species of Zamia, both of which are figured.

The *Coniferæ*, by the same author, as to the Brazilian flora, include only one *Araucaria* and two species of *Podocarpus*, all three most elaborately illustrated by figures, as also is *Cupressus Lusitanica*, an oriental Cypress, planted in Brazil. The interest of the article lies in a conspectus of an arrangement of the order, and in an *Excursus Morphologicus* on the structure of the flowers in *Gymnospermæ*. Dr. Eichler's arrangement throws the *Taxodineæ* as well as *Araucarieæ* into the suborder *Pinaceæ*, the former being supposed to have two superposed scales coalescent into one; the latter to have the proper carpellary scale obsolete.

The tribe *Araucarieæ* is characterized by multilocular anthers, the cells linear and hanging free, cupressaceous (i. e., simple and globose) pollen, simple scales to the female ament [which appear to answer to bracts and not carpophylls], inverted ovules, and naked buds.

The tribe *Abietineæ*, by bilocular anthers, with oblong and separate cells, pinaceous (rarely cupressaceous) pollen, double and separate scales to the female ament, inverted ovules, and scaly buds.

The tribe *Cunninghamieæ*, by the 2 or 3 short cells to the anthers, cupressaceous pollen, double scales to the female ament (the inner one smaller) but completely or incompletely coalescent into one body, inverted ovules, and mostly naked buds. To this tribe our author doubtfully refers *Sequoia!*

The tribe *Taxodineæ*, by the 3–5-locular anthers, with roundish apposite cells, cupressaceous pollen, the scales of the fertile ament double, nearly equal, and coalescent, or their tips free, the ovules erect, and the buds naked.

The suborder *Cupressaceæ* in this arrangement consists of only one tribe, *Cupressineæ*, with the usual characters, and including three subtribes, founded on the nature of the ament,—strobilaceous and closed, of peltate scales in the true *Cupressineæ*, strobilaceous but not peltate in *Actinostrobeæ* (of which *Thuja* is the Linnæan type), galbulaceous in *Juniperineæ*, and of free erect scales in *Diselmeæ* (*Diselma* Hook. f.).

The suborder *Taxaceæ* has four tribes; all but one with bilocular anthers; the *Dacrydieæ* with pinaceous pollen, an orthrotropous or rarely subanatropous ovule with its two integuments separate, and naked buds; *Podocarpeæ*, with its pinaceous pollen, an erect anatropous ovule, the integuments of which are coalescent; *Taxeæ*, with an anther of three or more cells, cupressaceous pollen, orthotropous erect ovules, scaly buds; and linear leaves; *Salisburyeæ*, differing from the last in the bilocular anthers, and the dilated fan-shaped leaves (in the Ginkko) or with the leaves reduced to teeth and phyllodineous expansion of the branches taking the place of foliage (in *Phyllocladus*).

The *Excursus Morphologicus*, without much striking novelty, is a very clear and cogent morphological disquisition upon the structure of the flowers of the *Gymnospermæ*. No good abstract can be now given without entering into the history of various recent discussions,—for which we are not yet ready. Suffice it to say, at present, that Dr. Eichler convincingly defends the gymnospermous doctrine, impugned by Agardh, Baillon, and Parlatore, and adopts and fortifies A. Braun's view that the inner or ovuliferous scale in the *Abietineæ* is a metamorphosis of an axillary diphyllous (in *Pinus*, or in *Cryptomeria*, &c., a 2–5-phyllous) shoot, the axis of which is undeveloped, and the leaves or scales united into one. Establishing the foliar nature of the carpophyllous scales, whether simple and of the first order, as in *Cupressineæ*, or of the second order and more or less compound, as in *Abietineæ;* and also settling it that each antheriferous scale, however many anther-cells it may bear, answers to one leaf and therefore to one stamen, he first compares Coniferous flowers with those of *Cycadeæ*, where he cannot doubt that the scales or leaves themselves bear the ovules; and so he naturally infers the same of the ovules of *Abietineæ* and *Cupressineæ* (according to the Brunonian

view); while the ovule of *Taxus*, &c., as in *Gnetaceæ*, is regarded as a direct metamorphosis of the axis. But, having settled that the whole of a simple male catkin of a Conifer, consisting of few or many stamineal leaves, developed in regular phyllotaxis on a simple axis, must logically be held to constitute one male flower (under which view the androecium of *Dammara* and *Araucaria* neatly homologizes with *Cycadeæ*), it follows that the whole female catkin of a *Cupressinea* would equally constitute one flower, while in a Pine or Fir each ovuliferous scale, and in a Yew, the ovule itself would be a flower. Unwilling to accept such a conclusion, which makes the ament of a Conifer in one case an inflorescence and in other apparently quite similar cases a single flower, Dr. Eichler propounds instead the idea that the female scales are not carpophylls, but bracts, not themselves really ovuliferous, but with ovules borne in their axils—as they evidently are in *Podocarpus* sec. *Stachycarpus*, and not far from it in most *Cupressineæ*,—although often adnate to their face. Each ovule, accordingly, is a flower, in all *Coniferæ* with simple scales; and this view is extended even to *Taxus* and *Torreya*, the ovule or flower of which is concluded to be only quasi-terminal. The female flowers, or ovules, in all the above cases are "*primo gradu axillares.*" But in *Abietineæ*, and in whatever other *Coniferæ* have their fruitful scales in the axil of a bract, the flowers or ovules are "*secundo gradu axillares.*" The female flower in all *Coniferæ*, accordingly, is concluded to be an ovule, and this is the metamorphosis of a lateral axis; while the leaves of a primary axis are metamorphosed into stamens. The latter we see frequent confirmation of in monstrous catkins of *Abies*, where some of the subtending bracts become polliniferous.

One good inference which Dr. Eichler draws from these morphological conclusions is that the *Coniferæ* constitute but one natural order, equivalent to *Gnetaceæ*, the highest of Gymnosperms, and to *Cycadeæ*, the lowest. The latter, in view of their analogies to Ferns and their simple foliar metamorphosis, he regards as the "archetype" or rather primordial type of Phænogams: while in the *Coniferæ*, which are analogous to *Lycopodiaceæ* as *Cycadeæ* are to Ferns, the metamorphosis affects the axis as well as the leaves. At length in *Gnetaceæ* a perianth and even structurally hermaphrodite flowers appear, realizing—though still on the gymnospermous plan—the floral type of ordinary Phænogamous plants. Dr. Eichler has studied and appreciated Dr. Hooker's paper on the wondrous *Welwitschia*, of which we gave some account in vol. xxxvi, p. 433, &c. What a pity this beautiful "synthetic type" did not come to light in paleozoic botany!

Finally Dr. Eichler adopts the view of Brongniart, that the Gymnosperms constitute a true natural class, intermediate between Cryptogams and Angiosperms. No new reasons are adduced in support of this view; but on the whole it must be admitted that the grounds for the maintainance of Gymnosperms as a peculiar type or class grow stronger; although we could not say with propriety that they are intermediate between proper Phænogamous and Cryptogamous plants.

The Brazilian *Ericaceæ*, elaborated by the practised hand of Meisner, are chiefly rich in *Vaccineæ*, and especially in *Gaylussacia*, of which, after large reductions, Prof. Meisner enumerates 36 Brazilian species.

Much as this tribe luxuriates in these regions, it appears not to furnish esculent fruit, as in our cooler northern regions. Of the proper *Ericineæ* the largest genus is *Leucothoë*, with 23 species. There are no *Pyroleæ*, and no *Monotropeæ* known as yet in the Brazilian Empire; but *Monotropa uniflora* occurs as near as the southern part of New Granada. A. G.

4. *Species Genera et Ordines Algarum;* auctore JACOBO GEORGIO AGARDH. Vol. II. pars 3 : 2. Lund, 1863. pp. 787–1291. 8vo.—We have had the gratification of receiving another and large instalment of this classical work. It comprises Agardh's Ordo XVI, *Rhodomeleæ*, consisting of seven tribes and thirty-three genera. Among them is an Australian genus, of two species, named *Cliftonia* by Harvey,—a name long ago pre-occupied in Phænogamic Botany. The work is as excellent in typography and arrangement as it is in scientific character. A. G.

5. *Phycologia Australica; a History of Australian Seaweeds.*—We take this opportunity to announce that Professor Harvey has completed this, perhaps the most beautiful and one of the most important of his unrivalled illustrated works. It forms five volumes, royal 8vo, containing 300 colored plates. It is published by Lovell Reeve & Co., and costs in London a little less than £8. A. G.

6. *Thesaurus Capensis*, &c. Vol. II, No. 1, 1863.—Professor Harvey, in the midst of indefatigable labors both in Algology and upon the Cape Flora, has found time to bring out during the past year the first part of a new volume of this illustrated work, containing plates 101 to 125 inclusive. The lithography is better than ever; and several of the plates are devoted to subjects of curious interest; five or six illustrate remarkable Orchids, and one exhibits an extraordinary *Pelargonium* with its petals slit up into fine shreds. *Montinia acris* is figured, and the fact mentioned that it has three-cornered pollen, so that it really belongs to the Evening-Primrose family after all. A. G.

7. *The Plants indigenous to the Colony of Victoria; described by* FERDINAND MÜLLER, Ph.D., M.D., F.R.S., &c. Vol. I, *Thalamifloræ.* 1860–1862. pp. 242, roy. 4to, with 23 plates.—When, in the number for September last, we noticed the *Flora Australiensis*, with which Dr. Müller is so honorably and usefully connected, we had not yet received our copy of the present publication. This is the first volume of a more detailed flora of Victoria Colony, with full ordinal, generic, and specific descriptions, and many critical observations; also with a considerable number of well-designed plates, executed in the Colony in a very hopeful manner. It is published by the Colonial Government, which appears to have been always ready to promote worthy scientific investigations. And we trust it will be carried to completion, notwithstanding the more comprehensive Australian Flora. A. G.

8. *Notice sur les Plantes de Michaux et sur son Voyage au Canada et a la Baie d'Hudson, d'après son Journal manuscrit et autres documents inédits;* par l'Abbé OVIDE BRUNET. Quebec.—The professor of Botany in the Laval University, Quebec, makes an appropriate *debût* in this interesting publication. It is a study of the botanical explorations and journeyings of the elder Michaux in Lower Canada and, by way of the Saguenay River and Lake Mistassius, nearly to Hudson's Bay.

While pursuing botanical studies at Paris, Prof. Brunet had noted with care, all the Canadian stations, in the herbarium of Michaux, and since his return he has been able to retrace every step of this hardy explorer and pioneer by means of his manuscript journals preserved by the American Philosophical Society at Philadelphia. Attention was first called to this interesting manuscript, and an abstract given, in our vol. xlii (old series) about twenty-two years ago,—chiefly referring, however, to Michaux's explorations in the Alleghanies of the Southern States. In the present article we have a full account of the northern exploration, in the summer and autumn of 1792, with lists of some of the principal plants collected at each station, and useful notes upon the geographical distribution or range of the forest-trees of the region.

Upon Michaux's remark that the *Gaultheria procumbens* disappears about ten leagues above Lake St. John, Prof. Brunet adds a foot-note relative to the name of the physician of Quebec to whom Linnæus or Kalm dedicated this well-known plant. Kalm wrote the name *Gaulthier;* hence *Gaultheria.* But, relying upon the French Academy of Sciences, in a volume of whose memoirs the name is written *Gautier*, Endlicher changed the orthography of the genus to *Gautiera.* Others have plausibly conjectured that his name was *Gualthier* or *Gualtier*, hence *Gualthieria* or *Gualtiera.* But Prof. Brunet has settled the matter by referring to the registers of the parish of *Notre-Dame de Quebec* (e. g., 1751, Aug. 26), where the signature of this physician is found, written *Gaultier. Gaulteria* or *Gaultheria*, the original form of the generic name, is therefore not much amiss, and scarcely needful to alter; although *Gaultiera* would be more correct, and may at length be made to prevail.

A. G.

9. *Botany of N. W. America along the British Boundary.*—Dr. David Lyall, the Surgeon and Naturalist of the British Commission for surveying this boundary, made a large and important collection of dried plants, to the excellence of which we bear grateful testimony. In the Proceedings of the Linnæan Society, No. 27 (1863), we find an interesting account: 1. of the character and extent of this botanical collection, and of the distribution of the duplicates (a complete set being laid into the Hookerian herbarium) to various public museums and botanists—"those having been selected in which (according to the authorities at Kew) they would be most beneficial to science." 2. "The General Character of the Regions traversed," from the Cascade Mountains to the plains of the Saskatchewan, is detailed. 3. "The Botanical Aspects of the Regions traversed" is considered at some length. 4. "Notes on the Distribution of the principal Trees met with near the 49th degree of latitude, and the elevation to which they reached, between the Gulf of Georgia and the Rocky Mountains," contains interesting matter relating to the *Coniferæ* of that region.

A. G.

10. *Ink-Plant* (*Coriaria thymifolia*).—Prof. Jameson, of the University of Quito, writes to Dr. Hooker, with ink consisting simply of the expressed juice of the berries of this *Coriaria*, remarking that he generally uses this in preference to ordinary ink, as it is not so apt to corrode the steel pen. The writing is at first reddish, but turns black in a few hours. He remarks: "There is a tradition here respecting this vegeta-

ble juice that merits attention. It happened, during the Spanish administration, that a number of written documents, destined to the mother country, were embarked in a vessel and transmitted round the Cape. The voyage was unusually tempestuous, and the documents got wetted with salt water. Those written with common ink became nearly illegible, whereas those written with 'Chauchi' (the name of the juice) remained unaltered. A decree was thereupon issued that the Government communications should in future be written with the vegetable juice. I do not vouch for the correctness of this statement, but I have constantly heard it repeated from different sources."—*Jour. of Proceed. Linn. Soc.*, No. 27.

11. *Botanical Necrology for the year* 1863.—Biographical notices have already appeared in this Journal of the lamented *Dr. Short*, who died on the 7th of March, and of *Dr. Darlington*, who died on the 23d of April last. The year 1863 has closed without farther additions to our home list. Of European botanists we have to record only the following:—

Professor Martin Martens, of the University of Louvain, who, in connection with Galeottii, published the collections of the latter in Mexico. He died Feb. 8, at the age of 75 years.

Dr. Christian von Steven, who botanized in the Caucasus many years ago, published several memoirs, and whose name is well known in connection with the Russian flora. He died at Sympheropol, on the 17th of April last year, at the venerable age of 91 or 92.

Prof. C. H. B. Alfred Moquin-Tandon, recently of the Faculty of Medicine at Paris, formerly Professor of Botany at Toulouse. He was a pupil of Dunal at Montpellier, and one of the earliest to take up the theory of *deduplication*, which he maintained in his inaugural thesis at Montpellier, published in 1826. His principal botanical writings (for he wrote also upon zoological and other subjects) are his succinct monograph of *Chenopodiaceæ*, published in 1840; his admirable *Elémens de Tératologie Végétale*, in 1841, and his elaboration of the *Salsolaceæ* (*Chenopodiaceæ*), *Amarantaceæ*, and the allied groups which mainly compose the second part of the thirteenth volume of DeCandolle's Prodromus:—so that he was one of the foremost botanists of the day.

And now with deep sorrow we have to add the name of

Francis Boott, M.D., who died at his residence in London on Christmas morning, in the 71st year of his age. He was born in Boston, on the 26th of September, 1792. His father, Kirk Boott, came to this country early in life, from Derbyshire, England, became a successful merchant in Boston, was one of the pioneers of manufacturing enterprise here, and one of the founders of Lowell,—the type, if not wholly the original, of New England manufacturing towns. His Boston residence was on the site now occupied by the Revere House, of which the Boott mansion forms a part. Francis Boott entered Harvard University in the year 1806, and took his Bachelor's degree in 1810. A year after, being then in his nineteenth year, viz., in the summer of 1811, he sailed for England, intending to enter a counting-room in Liverpool, as a preparation for mercantile life. This plan, however, was soon relinquished; and the three succeeding years were mainly spent with his relatives and their friends near Derby, where he made the acquaintance of Mrs. Hardcastle, his future mother-in-law, who was something of a botanist, and

where he formed both the scientific and social attachments which determined the aims and secured the happiness of his whole after life. Returning to Boston at the close of the year 1814, he engaged with enthusiasm in botanical pursuits, and amassed a good collection of New England plants. In the summer of 1816, he took a leading part in a botanical exploration of the mountains of New England, ascending, in the course of one journey, Wachusett, Monadnock, Ascutney, and Mt. Washington; and, later in the season, Dr. Boott with his brother visited and ascended Moose-hillock. His companions in the extended and then formidable tour which culminated in the White Mountains—then to be reached only by a laborious journey of two days on foot—were Francis C. Gray, Judge Shaw, Nathaniel Tucker, and Dr. Jacob Bigelow, the Nestor of New England botany, now the sole surviving member of the party. An interesting account of the ascent of Mt. Washington, written by Dr. Bigelow, was published at the time in the fifth volume of the New England Journal of Medicine and Surgery.

In the year 1820 Dr. Boott crossed the Atlantic for the last time, and, proceeding to London, entered upon the study of medicine, under the direction of the late Dr. Armstrong. He continued his medical studies at the University of Edinburgh, where he took the degree of M.D. in 1824. The next year he established himself in London, we believe in the very house in Gower street where he resided until the day of his death. He was soon associated with his near friend and former teacher in the work of instruction, becoming Lecturer on Botany in the Webb Street School of Medicine, where Dr. Armstrong was Professor of Materia Medica.

"His lectures are said to have been admirable, both in matter and style, and to have excited much enthusiasm; whilst his untiring efforts to promote the welfare of his pupils in other ways were so deeply and generally felt, that, on the eve of his too early withdrawal from the lectureship, they in one day raised a large subscription to present a testimonial to their friend and teacher;—a tribute which, with characteristic modesty and consideration, was declined as soon as heard of. He was, however, afterwards persuaded to accept a collection of books instead, in remembrance of their grateful feelings and good will."

The early death of Dr. Armstrong, cutting short a distinguished career, imposed upon his friend the duties of a biographer and expositor. Accordingly, after much preparation, Dr. Boott, in the year 1834, published two octavo volumes, entitled: "Memoir of the Life and Medical Opinions of John Armstrong, M.D.; to which is added an Inquiry into the facts connected with those forms of Fever attributed to Malaria and Marsh Effluvium." He published, besides, in the year 1827, two Introductory Lectures on Materia Medica, which give a good idea of his excellence as a teacher. Although he did not continue in this career, his interest in medical and scientific education never abated. He was an active promoter of the establishment of London University (now University College), and was for more than a quarter of a century an influential member of its Senate and Council. He was successfully engaged for some time in medical practice, and was for many years Physician to the American Embassy; but he gradually withdrew from professional cares and toils to more congenial literary and scientific pursuits. As

early as the year 1819 he had become a Fellow of the Linnæan Society of London; and afterwards, for the last twenty-five years, he gave it continuous and invaluable service as Secretary, Treasurer, or Vice President.

At one time it was thought that Dr. Boott might be recalled to his native country and to an active scientific life. Nearly thirty years ago he was offered the chair of Natural History in Harvard University,—a chair which had remained vacant since the death of Professor Peck in 1822, although its duties were for several years fulfilled by the late Mr. Nuttall. After Nuttall left Cambridge to explore Oregon and California, arrangements were made to endow the vacant professorship properly in case Dr. Boott would accept the place. Although the offer was declined, we have been told that he intimated a willingness to accept it if the chair were simply that of Botany; and when informed that he might practically make it so, although the title was unchangeable, he insisted that he would not be called a professor of Natural History, while he could pretend to a knowledge only of Botany.

Nearly thirty years ago, Dr. Boott began seriously to devote his energies to the special work upon which his scientific reputation mainly rests, viz., to the study of the vast and intricate genus *Carex*. The first result of these studies appeared in his elaboration of the *Carices* of British North America in Sir Wm. Hooker's Flora Boreali-Americana, published in 1840. Other papers upon *Carices* were contributed to the Transactions of the Linnæan Society, the Journal of the Boston Society of Natural History, &c. As it had always been the greatest pleasure, we might say the business, of his life to assist others, so now friends and correspondents from all parts of the world hastened to place in his hands the fullest sets of their collections in this difficult genus; and he was able to study, in the unrivalled caricological collection he thus formed, and in the various public and private herbaria to which he had access, almost all of the 600 or more species which the genus was computed by him to comprise, to compare them in numerous specimens of their various forms, and to examine them, group after group, with untiring and closest scrutiny. At length, early in the year 1858, he gave to the world (literally *gave to the world*) the first volume of his great work, entitled Illustrations of the Genus Carex, a folio volume with 200 plates, admirably representing about that number of species. A very large proportion of them were North American species, in which he naturally always took a special interest. In the letter of dedication of this work to his friend John Amory Lowell, Esq., of Boston, Dr. Boott states that his original design "was limited to the illustration of the *Carices* of North America," but that the large collections brought by Dr. Hooker from the East Indies, and placed in his hands for study, caused him to extend his plan, and to endeavor to illustrate the genus at large. With characteristic modesty he makes no allusion to the years of labor and the large amount of money (savings from a moderate income by a simple mode of life) which the volume had cost him; the drawings, engravings, and letter-press having been produced at his sole individual expense, and the larger part of the copies freely given away. Nor did he put forth any promise to continue the work. But in 1860 Part Second quietly appeared, without a word of preface. This contains

110 plates. Two years after, this was followed by Part Third, with 100 plates, making 410 in all; and it is understood that the materials of a fourth volume are left in such forwardness that it may perhaps be published by his surviving family.

Our own estimate of this work has been recorded in the pages of this Journal, as the successive volumes were received. The motto which the author placed upon his title-pages:—

> "The man who labors and digests things most,
> Will be much apter to despair than boast,"

is felicitously expressive both of the endless difficulties of the subject, and of his undervaluation of his endeavors to overcome them. A most competent judge briefly declares that,—

"This work is certainly one of the most munificent contributions ever made to scientific botany, besides being one of the most accurate; on which account it certainly entitles its author to take a much higher place amongst botanists than that of an amateur, which was all that his modesty would allow him to lay claim to."

Dr. Boott's health, which had long been delicate, was much shattered in the winter of 1839–40 by a dangerous attack of pneumonia. "From this time he had repeated slight attacks; but no alarming symptoms occurred till June 1863, when the remaining lung gave way, and from that time he never fairly rallied. He died at his residence, 24 Gower street, on Christmas Day,—retaining to the last his faculties and all the characteristics of his most admirable life."

Dr. Boott was a man of singular purity, delicacy, and goodness of character, and of the most affectionate disposition. Few men of his ardent temperament and extreme sense of justice ever made less enemies or more friends. To the latter he attached himself with entire devotion. If there were any of the former, probably no man ever heard him speak ill of them. His published works suffice to place his name imperishably upon the records of science. But only his contemporaries and friends will know how much he has done to help others, and how disinterestedly and gracefully that aid was ever rendered. He took with him to England, upon his return in the year 1820, a valuable herbarium of New England plants, especially those of the White Mountains, which were then rare and little known. He must have valued this collection highly, and have expected to use it. But he presented the whole of it to Dr., now Sir Wm. Hooker, when he saw how serviceable it would be to him in the preparation of the *Flora Boreali-Americana*. His British herbarium was long ago similarly given to a then young American botanist. Another who, twenty-five years ago, called to take leave of him upon returning to this country, found, as he left, the seat of his cab loaded with choice botanical books, which Dr. Boott had at the moment sent there from the shelves of his own library, where they were not duplicates. We know of one or two instances where he had commenced a critical study of a particular genus with a view to publication, but, upon learning that another person had taken up the same subject, he despatched to him his own notes and other materials. The Linnæan Society of London owes no little of its present prosperity to his long and faithful services and his wise counsels. He kept up an active correspondence with his friends in this country;

and for more than thirty years our young professional men, naturalists, and others who have visited Europe, have experienced cordial welcome and thoughtful kindness at his hands. The following gives a good idea of the man:—

"When practising as a physician he discarded the customary black coat, knee-breeches, and silk stockings, for the very good reason that sombre colors could not but suggest gloomy ideas to the sick; and he was one of the first who adopted the custom, now universal in the profession, of dressing in ordinary costume. In doing this Dr. Boott adopted the blue coat, gilt buttons, and buff vest of the period, which he continued to wear to the last, and with which dress his casual acquaintance, no less than his personal friends, will ever associate him. In person he was so tall and thin as almost to suggest ill-health; and the refinement of his manners, his expression, address, and bearing were in perfect keeping with his polished mind and many accomplishments."

The preceding extracts are all from an excellent article in the Gardener's Chronicle for January 16, to which we are much indebted. In the first volume of the late Dr. Wallich's splendid *Plantæ Asiaticæ Rariores*, published in the year 1830, is the figure of a handsome and curious Butomaceous plant, Boottia cordata, a genus dedicated "*in honorem Francisci Boott, Americani, botanici ardentissimi et peritissimi, amici dilectissimi, non minus animi probitate quam scientiarum cultu, et morum suavitate egregii.*" A. G.

Jacques Gay.—We have just heard of the death of this excellent man and botanist, but without details. The event must have been sudden, as we had news of him almost down to the close of the year. He was born in Switzerland, was a pupil of Gaudin, who bequeathed to M. Gay his herbarium; but most of his years, which were little under fourscore, were passed in Paris. The weekly *réunion* of botanists in his modest apartments at the *Petit Luxembourg*, which has continued through a long life-time, is now done away; and to botanists Paris will seem other than it was, without him. A. G.

V. ASTRONOMY.

1. *Comet IV*, 1863.—This comet was discovered by M. Tempel at Marseilles on Nov. 5th. It was visible to the naked eye, shining as bright as a star of the 5th magnitude. It appeared as a condensated nebula, showing a tail about 2° long. The following elements were computed by Mr. H. Romberg.

$$\begin{aligned} T &= 1863, \text{ Nov. } 9{\cdot}49923, \text{ Greenwich m. t.} \\ \pi &= 94^\circ\ 46'\ 10''{\cdot}6 \\ \Omega &= 97\ \ 31\ \ 15\ \ {\cdot}2 \\ i &= 78\ \ \ 6\ \ 46\ \ {\cdot}5 \\ \log.\ q &= 9{\cdot}849148 \end{aligned}$$

Apparent equinox Nov. 13·5.

Motion direct.

The following are some observations of this comet.

	m. t. Lubeck.	R. A.	Dec.
Nov. 19,	$18^h\ 30^m\ 43^s{\cdot}0$	$13^h\ 19^m\ 32^s{\cdot}02$	$+13^\circ\ 22'\ 2''{\cdot}0$
20,	18 10 41 ·0	13 27 46 ·81	+14 48 50 ·2

	m. t. Greenwich.	R. A.	Dec.
Dec. 3,	$6^h\ 16^m\ 17^s$	$15^h\ 46^m\ 35^s{\cdot}8$	$+30°\ 16'\ 17''$
	m. t. Josephstadt.		
Dec. 8,	5 48 50	15 46 9 ·04	+30 14 15 ·2

This comet was seen during November and December by several persons in this country, having been visible to the naked eye, and by some was confounded with the comet discovered by Prof. Watson Jan. 9th.

2. *Comet V*, 1863.—This comet was discovered on Oct. 9th by Mr. Bäcker at Nauen. The following elements were computed by Mr. Hermann Romberg.

T = 1863, Dec. 27·70863, Greenwich m. t.
π = 180° 17′ 53″·4 } Apparent equinox
Ω = 104 51 28 ·8 } of Oct. 14·5.
i = 82 16 29 ·4
log. q = 0·131934
Motion direct.

This comet appeared as an oblong nebula, strongly condensed in the middle. Its diameter was about 1′, and it shone as a star of the 8th magnitude.

3. *Comet VI*, 1863.—On the 28th of December, 1863, M. Respighi, Director of the Observatory at Bologna discovered a new comet (the sixth of 1863). It exhibited a nebulosity condensed toward the centre, with the trace of a tail about half a degree in length. The following are two observations of Dec. 28th.

m. t. Bologna.	R. A.	Dec.
$6^h\ 43^m\ 4^s$	$18^h\ 49^m\ 24^s{\cdot}80$	$25°\ 57'\ 33''{\cdot}7$
18 11 2	18 50 1 ·76	26 13 2 ·2

M. E. Weiss has calculated the following elements of this comet.

Perihelion passage,	1863, Dec. 27·9915
Longitude of perihelion,	60° 31′ 22″
Longitude of node,	304 47 17
Inclination,	64 43 40
Perihelion distance,	0·77301
Motion direct.	

M. Weiss remarks that these elements resemble those of the comets of 1490 and 1810, the three perihelia being separated by intervals of $53\frac{1}{3}$ years, and of $320 = 6 \times 53$ years.

	Comet of 1490.	Comet of 1810.
Perihelion passage,	Dec. 24·477	Sept. 29·1062
Longitude of perihelion,	58° 40′	52° 44′ 42″
Longitude of node,	288 45	310 21 2
Inclination,	51 37	61 11 15
Perihelion distance,	0·7376	0·97579
Motion	direct.	direct.

This comet was discovered at Ann Arbor on the 9th of January, as announced in the following letter from Prof. Watson:

"Observatory, Ann Arbor, Michigan, 1864, Jan. 13.

GENTLEMEN:

I have the pleasure to inform you that I discovered a new comet on the evening of Saturday, Jan. 9th, at 6½ o'clock. I have observed the following accurate positions:

Ann Arbor M. T.	Comet α.	Comet δ.
1864, Jan. 10, 6h 57m 7s	19h 14m 3s·37	+34° 6′ 5″·9
11, 6 18 57	19 17 15 ·31	34 52 52 ·2
12, 6 5 51	19 20 53 ·35	35 42 47 ·0

From these places I have derived the following elements of the orbit:

T = 1863, Dec. 27·1413 Washington M. T.
π = 60° 17′ 39″·0
Ω = 304 40 49 ·0 } App. equinox, Jan. 11th.
i = 63 55 38 ·5
$\log q$ = 9·885810
Motion direct.

The comparison of the middle place gives:

c.—o.
$\Delta\lambda \cos\beta = -2''·9 \quad \Delta\beta = -15''·0$

The comet is large and bright, with a tail 1½° in length, and a nucleus strongly condensed at the centre.

The above elements almost exactly resemble those of the comet of 1810, so that there can be very little doubt of the identity of the two comets. Whether this is the first return to the perihelion since 1810, or whether it has returned several times unperceived, must be decided by subsequent observations. Very truly yours,

JAMES C. WATSON."

This comet was barely visible to the naked eye during the latter part of January, and in a comet-seeker exhibited a tail about 2° in length.

4. *Notes on η Argus;* by F. ABBOTT, Esq. (from Proceedings Royal Astronomical Society, Nov. 13, 1863.)—That the duration of this star's apparition is variable to a great extent is certain; and by comparing the present description with the monograph of Sir J. Herschel, taken at Cape of Good Hope, it will, I think, appear conclusive that the apparition of the surrounding nebulæ is also variable.

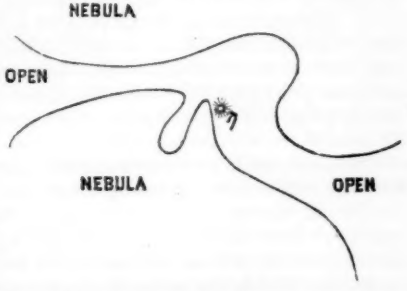
Messier recommended careful observations to be made on such objects, with a view to ascertain whether or not any indications of change in form or structure are exhibited. That such changes have taken place is already on record. An instance is afforded by the remarkable nebula surrounding θ in the constellation of *Orion*, which Huyghens discovered in 1656, and noted in his *Systema Saturnium;* from comparison of which Sir Wm. Herschel, by his own observations from 1783 to 1811, concluded it had undergone sensible change. Bouillard and Le Gentel maintained the same opinion in reference to the nebulæ in *Andromeda;* and of later date, Bond, Pogson, Struve, D'Arrest, and others, have observed such changes.

Sir John Herschel, when at the Cape, carefully examined *η Argus* with an 18-inch reflector; "No part of this nebula," says Herschel, "shows

any sign of resolution into stars." "It is not easy," he adds, "for language to convey a full impression of the beauty and sublimity of the spectacle which the nebula offers as it enters the field of the telescope." "It will appear," he also writes, "that every succeeding state of nebulous matter is the result of the action of gravitation, and by such steps the successive condensation of it is brought to a planetary or stellar condition. Several instances are on record which connect the planetary with the stellar appearance. In those instances wherein the collection of nebulous matter was very extensive, subordinate centres of attraction could not fail to be established, around which the adjacent particles would arrange themselves, and thus the whole mass would, in process of time, be transformed into a determinate number of discrete bodies, which would ultimately assume the condition of a cluster of stars."

That this condition is partly carried out in the object *η Argus* will be manifest by comparing the Cape description with the present one. A great difference may be caused by the optical means employed, as far as resolvability goes; but if an increased number of brilliant isolated stars, with a change in position of *η Argus*, is the effect produced by a 5-foot achromatic, and they were not exhibited to the same effect in an 18-inch reflector, it only strengthens the evidence in favor of some change having taken place in the object.

The open space, as given in the Cape Monograph, and also in the last edition of the *Outlines*, is somewhat in the form of a dumb-bell, compressed in the centre and surrounded with nebulæ, in the most dense part of which is situated *η Argus*. The appearance of the open space now assumes the form of a crooked billet, wide in the centre and open at both ends, with *η Argus* situated within the open space or dark part, and surrounded with an almost innumerable quantity of brilliant stars, many of which are arranged in groups, some being of a blue, and some of a ruddy color. They are remarkably brilliant in the dark space, and afford a good comparison with the variable star itself.



It appears somewhat paradoxical that in 1838, when examined by Sir J. Herschel, the star *η Argus* was situated in the most dense part of the nebula, and was seen as a star of the first magnitude. And now in 1863, it is out of the nebula, and, within the dark space, it appears only as a star of the sixth magnitude.

That the star's right ascension has not varied so much will be manifest. It is clear then that the dense portion of the nebula, towards the east, must have receded, leaving each end open, and *η Argus*, together with about 70 stars ± up to the 14th magnitude, as seen within the dark space.

The irregularity of this star, and the nebulosity surrounding it, involve

a principle as to whether its accession and diminution is the effect produced by distance, transits of opaque bodies, or solar spots; or whether the nebulosity surrounding *η Argus* interferes with the light emitted by the star; if so, the increase and diminution, however vacillating, become obvious.

VI. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Account of the casting of a gigantic (Rodman) Gun at Fort Pitt Foundry*, (in a letter to the Editors, dated Pittsburgh, Penn., Feb. 1864.) —A 20-inch army gun on Rodman's plan, has lately been cast at the Fort Pitt Foundry in this city. Being the largest iron gun in the world, its manufacture necessarily awakened much interest here. Thinking therefore that your readers may feel a like interest, I take the liberty of sending you the facts of the casting, as well as the theory of this improved method.

It has long been known that there is a practical limit to the manufacture of large iron guns, cast solid, beyond which the size cannot be increased. This arises from the method of cooling, which is entirely from the exterior. Of course the first part to become solid is this exterior surface. As the cooling progresses, and the solidification proceeds toward the centre, the iron contracts and produces an enormous tension, acting in opposite directions—that is radially, in the cross section. A force of compression is felt on the exterior, to crush it inward; and one of radial elongation, exerted from within outward, on the interior, to tear it asunder. This condition of things in glass is well illustrated in the Prince Rupert's drop. In the case of solid cast iron shot, for example, there is a maximum diameter within which these can be cast without containing cavities. But beyond this point, the contraction toward the exterior, which is the first to solidify, is so great that these cavities are formed. In general the contraction is irregular and the cavities are near the upper surface. Hence it is considered preferable to cast thick shells, in which case the core locates the cavity exactly in the centre. For the same difficulties in casting large guns, it was at first proposed to apply the same remedy. That is, to cast the gun with a core, so that the contraction should be uniform from the axis to the surface.

Major—then Lieutenant—T. J. Rodman had his attention first called to the manufacture of guns of this sort,—as he recently stated before the Committee on the conduct of the war,—from the lamentable accident which occurred on board the steam frigate Princeton, in 1844. The "Peacemaker" was a wrought iron imported gun, having a bore twelve inches in diameter. Considering the conditions under which iron guns were usually cast, Major Rodman at once saw the enormous strain to which they were subjected by exterior cooling. And he also perceived that a gun thus cast was in a state of extreme tension and therefore weak. He then applied himself to the mathematical investigation of the conditions under which a central force acts. He found that Barlow had determined that the strain produced upon any material by a central force, diminishes as the square of the distance from the centre increases. Thus in a gun one calibre thick the distance from the bore to the exterior is 3, and the strain on the exterior when fired is only $\frac{1}{9}$th that on the interior. Now if the strain at the interior is the breaking strain, then this

being 1, and that at the exterior being $\frac{1}{3}$, that of each infinitely thin cylinder between these surfaces being intermediate, the effective strength of the whole will be the sum of these strains. This resistance is found to be "two-thirds of that which half a calibre in thickness would offer if the strains were all equal, as in the tensile strain." So that the resistance which a hollow cylinder, such as a gun, opposes to a central force, is, when the interior is at the breaking strain, only $\frac{2}{3}$ of that which $\frac{1}{2}$ the same thickness would oppose the rupturing of a bar of it longitudinally. And this only when the gun is entirely free from previous strain, cooled theoretically; that is, simultaneously throughout. But in the manner in which guns cast solid are cooled, we have seen that their contraction induces an enormous strain: and that this acts radially; from the circumference and the centre toward each other, tending to draw the exterior inward and the interior outward. Now this strain, produced by exterior cooling, acts in conjunction with the central force produced by the explosion of the powder, to burst the gun. This central force we have just stated gives nine times the pressure on the *interior* of a gun one calibre thick that it exerts on the *exterior*. Hence it tends to force the interior outward. But the tension in cooling acts in the same direction. And this latter force far exceeds the former, if we remember Major Rodman's statement that the interior of a gun may be burst by firing, without the tension outwardly, produced by the explosion, equalling that inwardly, given originally by contraction: hence without relieving the exterior strain.

The first plan suggested by Maj. Rodman to obviate this difficulty in the way of casting large guns, was to cast them with a core. This core allowed of some compression as the iron cooled and contracted around it. To accomplish this, he proposed to cut a thread upon the core and wind it with a wire, shaped like an H in the cross section. One of the straight sides would lie in one groove, the other in the adjoining one, and the connecting part would bind the core together longitudinally. The difficulty of procuring this peculiar shaped wire led him at last to abandon this plan. Then it was that the idea suggested itself to him of using a hollow cylinder of iron for the core, in which a stream of water should circulate. By this means the direction of cooling would be inverted, and as the interior would cool first, the contraction would take place from the exterior inward. He thus expected to oppose the action of the powder to burst the gun, instead of facilitating it. Instead of the resistance opposed to the powder being even as it is in the theoretical gun, above alluded to, $\frac{2}{3}$ds of that of the entire strength of a bar half the thickness—and of course far less in the gun cast solid—he so regulates the contraction that all the theoretical cylinders in the gun shall be brought to the breaking strain at the same instant. A condition of things in which the resistance is twice, instead of $\frac{2}{3}$ds of that given by a bar half the thickness. This is attained by having the contraction toward the centre, binding the theoretical cylinders of the gun one upon the other, as in the process of shrinking. Moreover, that part of the gun which cools most rapidly is hardest. By interior cooling, the bore is the part soonest cooled and in these guns it is less subject to wear than when it is the last part to cool, as in the old method.

The plan thus devised was offered to the Ordnance Department three several times during the years 1845 and 1846. But they thought it impracticable, and so far from adopting it they were not even willing to make a trial of its merits by actual experiment. Finally, in 1847, Major Rodman, then stationed at the Alleghany Arsenal, offered it to Messrs. Knap & Totten, proprietors of the Fort Pitt Foundry, Pittsburgh. They agreed to make a trial of the principle at their own expense and also to defray the expense of securing a patent, if he would assign one-half of his right in it to them. This he agreed to do, and the patent was accordingly issued in August, 1847. Preparations were immediately commenced and the first hollow cannon was cast at that Foundry in the winter of 1849–50. This was an 8-inch Columbiad. At the same time and from the same metal a solid gun of the same size was cast. When finished, they were proved with a charge of 10 lbs. powder and one 64 pound shot. The gun cast solid burst at the 85th fire: the one cast hollow at the 251st. In 1851, the experiment was repeated in a similar manner, with only such slight variations as experience had suggested. The guns were of the same size as in the previous experiment. The one cast solid burst at the 73d fire, the other has endured 1500 rounds and is still unbroken.

These experiments continued with the same or nearly the same form of gun until 1859, Major Rodman being engaged in experiments to determine the relative merit of the interior mode of cooling, not only by the service proof, but by ascertaining the resistance of iron of various qualities, prepared in various ways, by methods as nearly resembling the force of powder as possible. From these investigations, he came to the conclusion that the old columbiad model was radically defective. He therefore spent that year in experimenting to determine the explosive force of powder on different parts of the bore of the gun at the same instant; and the ratio of diameter to length necessary to equalize the strains tending to transverse and to longitudinal rupture. From these data, he obtains the strain, and the consequent amount of resistance required at each cross section of the gun, which gives the thickness of metal. Plotting these results, he produced the beautiful model known as the "Army gun," which far surpasses in appearance the "Navy gun," modeled by Admiral Dahlgren.

The first gun on the new model was cast at the Fort Pitt Foundry, December 22d, 1859. It was a larger gun than had ever been made successfully on the old plan. The diameter of the bore was 15 inches; the exterior diameter at the breech, 48·1 inches; total length 15 feet 10 inches; weight 49,099 lbs. This gun when finished was transported to Fortress Monroe and proved. It has been fired 505 times with full charges, and four times with smaller charges, and it is still unbroken.

Major Rodman having thus admirably demonstrated the practicability of constructing these immense guns, and their perfect safety within 1000 rounds, it only remained to increase the size of the guns thus made, until a limit should be reached. Accordingly in April, 1861, in a report made by him to the Ordnance Bureau, he recommended the construction of a gun, whose bore should be 20 inches in diameter. Owing however to the great demand for large guns, of the size already made, no attempt to cast this immense gun was made until the present winter.

The Fort Pitt Foundry stands on the Alleghany river, resting on made land. As guns are cast vertically, with the muzzle up, the first thing to be done is to sink a pit, as deep as the intended gun is long. In this instance the requisite depth would carry the bottom of the pit below the water line and water would flow in. A wrought iron tank fills up therefore half the height of the pit: and this is lined with a layer of brick 9 inches thick, which is continued to the top. A circular pit 30 feet deep and 14 feet in diameter is thus made. Within this the flask, or support for the moulding sand, is placed. It is circular in section, divided longitudinally into two parts, and transversely into three. The metal is about 1½ inches thick and is strengthened by heavy cast ribs. Its diameter is 6 feet and its weight 32 tons. It was cast by Mr. Joseph Pennock, at the Fulton Foundry. The wooden gun pattern, in two halves, which is 25 feet in length, maximum diameter 5 ft. 6 inches, and diameter at the muzzle 4 feet, is about the size of the rough gun. One half containing one trunnion is moulded in each half of the flask. The mould is then dried by heat, the two halves clamped and bolted together, and the whole lowered into the pit. It weighs 53 or 54 tons. The core-barrel is a hollow cylinder of iron 17 inches in diameter, closed at one end, open at the other. It is about one inch thick and is grooved longitudinally or fluted, like a column in architecture, its entire length, the furrows being ½ an inch apart. Around this is wound a rope of the size of ordinary bed cord, and over this a layer of clay ¾ inch thick is evenly spread and the whole dried. The object of the grooving is to allow the free escape of gas. The rope prevents the clay from filling up these grooves. This core thus prepared is lowered into the mould, and maintained exactly in the centre by a heavy collar bolted down to keep it from rising. A copper pipe passing to the bottom of the core supplies the water: while another pipe opening into the top leads off this water after it has become hot in the core-barrel.

The furnaces are constructed on the reverberatory plan, the hearth inclining toward the fire. They are known as air furnaces, and depend on draft entirely. They were charged cold with second fusion Bloomfield pig iron; No. 4 receiving 39 tons, No. 5 and No. 6, 23½ tons each. No. 3 was charged with 18 tons and held as reserve. The fires were lighted in these furnaces at $4^h\ 15^m$ on the morning of Thursday, Feb. 11. The day was fine and the barometer high; the draft was therefore good and the iron was all in fusion at $11^h\ 30^m$. Low iron, or that containing an excess of carbon, is soft and weak: high iron containing less carbon is harder and more tenacious, but it contracts more in cooling. Hence the iron in the furnaces was tested from time to time to ascertain when it reached the right point. At $12^h\ 24^m$, the three furnaces were tapped simultaneously. The metal was conducted in runners to a pool near the pit, from the side of which, near the bottom, it passed in two runners to the gun mould, entering, not directly, but through side channels or gates, having branch gates inclined upward toward the axis, at intervals of 12 inches. The scene just at this time was grand. Three streams of liquid fire, throwing out most brilliant coruscations, after a course of fifty feet or more, fell into a sea of the molten metal, again to emerge in two others which ran to, and disappeared in the vast iron frame. Away down in

the gun-mould could be seen the boiling metal slowly rising toward the top. The moisture of the sand yielded up its hydrogen: the rope furnished carbonic oxyd; and the sticks with which the surface of the metal was constantly stirred added to the flame: until it seemed as though an abyss had opened into the internal fires of the earth. Water at a temperature of 36° F. had been admitted to the core-barrel before tapping the furnaces, and it then left at the same temperature, the flow being 30 gallons per minute. At $12^h\ 45\frac{1}{2}^m$, the mould was full and the flow from the furnaces was stopped; the entire time of casting being $21\frac{1}{2}$ minutes. At this instant, the water left the core barrel at 42°. At 4^m thereafter 52°; $8^m - 65\frac{1}{2}°$; $14^m - 81\frac{1}{2}$; $25^m - 91°$; and at $30^m - 91\frac{3}{4}°$. One hour after casting, this flow of water was increased to 60 gallons per minute. At two o'clock a collar was put on the flask and more metal was added to increase the length of the 'sinking head.' More effectually to retard external cooling, grate bars were placed near the bottom of the pit, around the flask, and the fire on them was lighted at $3\frac{3}{4}$ o'clock. The flow of water was continued till A. M., February 12. Then the core barrel was removed, after some little delay, at $2^h\ 45^m$. With very high iron it is deemed possible to cool the interior so rapidly as to fracture the exterior. As this iron was pretty high, it was not considered advisable to proceed as usual, that is to circulate water directly in the bore of the gun, but to substitute air therefor. A sheet iron pipe 8 inches in diameter was carried to the bottom of the bore and a stream of air driven continuously through at the rate of 2000 cubic feet per minute. This air commenced to flow at $2^h\ 57^m$ on the 12th, and continued uninterruptedly until the gun was cold. On the 19th at $3^h\ 30^m$ P. M. the air issued at the temperature of 70° F., the fire in the pit having been extinguished the night previous. On the 23d, the gun was stripped; i.e., the flask was removed from its surface. A solid cylinder of the metal for trial, 2 inches in diameter and 4 inches long, was taken out about two feet from the top. But in removal it fractured across the spongy portion, about three inches from the exterior. So that of the thickness of the gun $14\frac{1}{2}$ inches, $11\frac{1}{2}$ formed the interior shell. A second specimen was taken, 4 inches below the muzzle, that is 4 ft. 4 in. below the top of the sinking head. This on testing gave density 7·3028 and tenacity 28737. The iron was very uniformly mottled and appeared of excellent quality. On the 24th, the casting was still perceptibly warm at its lower end. The stream of air was therefore continued until the 25th. Then by means of two immense steam cranes, this huge gun, weighing 86 tons, was lifted from its pit, and prepared for the lathe. The casting was perfect. All these facts, therefore, indicate that 20-inch guns are as easily made as 15-inch.

The dimensions of this gun when finished will be as follows:—Total length over all, 20 ft. $3\frac{1}{2}$ inches. Length of bore 210 inches. Maximum diameter 5 ft. 4 inches. Diameter at the muzzle, $33\frac{1}{3}$ inches. Diameter of bore, 20 inches. Total weight, 112000 lbs. The weight of the shot, supposing it solid, would be 1000 lbs. A service shell of this size, $3\frac{1}{2}$ inches thick, would weigh 725 lbs.; a battering shell, $6\frac{3}{4}$ inches thick, 925 lbs. The charge of powder required would be about 100 lbs. Nine men could load it as easily as five now load the 15-inch gun. The living force of the service shell above mentioned, in crushing the sides of an

iron-clad, would equal that of *six ten-inch solid shot:* and that of the battering shell would considerably exceed that of *seven ten-inch solid shot.*

This gun being entirely experimental, Government only pays the expenses of manufacture. On all guns cast hollow, however, the patentees get one cent per pound royalty.

The casting of this gun took place under the supervision of Major Dyer, of the Springfield (Mass.) Armory; Major Rodman, of the Arsenal, Watertown, Mass.; and Capt. Benét, Inspector-in-chief of Ordnance, West Point, N. Y.: all of the Army. And there were present Capt. Aulick, of the Ordnance Bureau, and Capt. Berrian, Inspector of cannon and projectiles at this station, of the Navy. Capt. Goodenough of the Royal Navy, and the Marquis de Basse Court, of the Italian Navy, were among the distinguished spectators.

This immense Foundry is now carried on by Charles Knap, Esq. He has for his foreman Mr. Joseph Kaye, acknowledged to be the best gun founder in the country. G. F. B.

VII. BOOK NOTICES.

1. *First Outlines of a Dictionary of the Solubilities of Chemical Substances.* By Frank H. Storer. Part II.—The importance which we attach to Mr. Storer's work now in process of publication leads us to make some further observations on the second part which appeared a few months since. This portion of the work confirms the impression made by the first; it is characterized by the same pains-taking accuracy, and the same clear conception of the requirements of his subject.

This second part begins with convolvulinolic acid and ends with oxyd of tin; it embraces many large and important chemical groups, such as the cyanates, cyanids, fluorids, iodids, the ethylosulphates, hydrates, nitrates, oxalates and part of the oxyds. With respect to all of these, copious and minute information is afforded, derived from an exceedingly large number of sources, as is sufficiently evinced by the great number of references given. As a single example, we may remark that the solubility of nitrate of potash in various menstrua is illustrated by no less than sixty-three quotations from authors on the subject.

The advantages of a work like this are two-fold. For it not only aids the chemist by placing in an acceptable shape the information which he desires, but it will be found, in our opinion, to afford a decided stimulus to the completion of an exact knowledge on the subject to which it is devoted. It exposes, by a significant silence, the points which have been overlooked or neglected, or relative to which no observations have been made; thereby inviting active chemists to fill up these lacunes and complete our knowledge. Mr. Storer has moreover given very conscientiously his authority for by far the greater number of his statements, therein following the excellent example set by Leopold Gmelin; which is gradually becoming more and more generally imitated by chemical writers. This system is satisfactory in the highest degree both to the reader and to the authors quoted. To the latter, it aids in giving the just reward of their labors, that consideration and reputation which together with honest and hearty love for the study, is so often the only recompense that falls to the lot of the really scientific chemist. To the

reader, it is equally valuable, for in the case of conflicting statements it enables him at least to form some opinion as to which are most likely to be reliable, and as to the necessity of further investigation.

The book is indispensable to the chemical student. We feel the want of the third part, for the sulphates, phosphates and tartrates, etc., and shall welcome its appearance. M. C. L.

2. *Chambers' Encyclopedia: a Dictionary of Universal Knowledge for the People.* Illustrated. Philadelphia: J. B. Lippincott & Co. Edinburgh: W. & R. Chambers. 1861–1863. Vols. I–V, royal 8vo, pp. 828 each.—We have in a previous volume of this Journal noticed the commencement of this valuable publication. It has now reached the completion of the fifth volume, bringing the alphabet down to the letter L. It is constructed on the general plan of the Conversations-Lexicon of Brockhaus, and, like its great prototype, is characterized by variety, conciseness, and accuracy. The articles on scientific topics are numerous and remarkable for exactness and brevity. The error is nowhere committed of extending such notices beyond the proper limits of a dictionary of knowledge to the dimensions and scope of elaborate treatises. The spirit of the original 'Cyclopedia' of Ephraim Chambers —now more than a century old—has been revived by his namesakes in the present work, his original plan—very like that of the German Conversations-Lexicon—having been widely departed from in many similar works of subsequent date. By a liberal use of wood-cuts in the text the value of this Encyclopedia has been much increased. Such illustrations are used whenever the subject demands them, and they are generally of excellent quality. The work is printed from the English plates, and is published in cloth at $2.80, sheep $3.20, half turkey $3.60, and will be completed in seven or eight volumes.

3. *A Practical Handbook of Medical Chemistry;* by John E. Bowman, F.C.S. Edited by Chas. L. Bloxham, Prof. of Practical Chemistry in Kings College, London. Third American from the fourth London edition. Philadelphia: Blanchard & Lea.—Important additions have been made to the present edition, especially in the examination of urine by the volumetric methods, and for poisons in organic mixtures by a general systematic course of detection. Prof. Graham's methods by dialysis are also introduced, and the electrolytic detection of metals is revived.

4. *Dana's Manual of Geology.*—A revised edition of Dana's Manual of Geology has just been issued by the publishers (T. Bliss & Co., Philadelphia), containing, besides some other additions, a woodcut of the long-tailed Bird of Solenhofen, copied from the last December number of the Intellectual Observer (illustrating in that Journal an article by Mr. H. Woodward), and another of a new Insect from the Carboniferous rocks of Illinois.

OBITUARY.

Edward Hitchcock.—Professor Edward Hitchcock died at Amherst, Massachusetts, Feb. 27th, at six in the morning, aged seventy years and nine months. He was born at Deerfield, Mass., May 24th, 1793. Although enjoying limited advantages of early education he had the position of Principal of the Academy in his native town, from 1815 to 1818, during which time he also edited an almanac. In 1811, when only 18 years of age, he made observations on the comet and solar eclipse of that

year. His first geological paper, and in fact his first important contribution to science, was his "Remarks on the Geology and Mineralogy of a section of Massachusetts on Connecticut River," published with a map in the first volume of this Journal, and dated at Deerfield, Oct. 1817. From 1818 to 1825 he was the Pastor of a church in Conway, Mass., still pursuing his scientific studies as is evident from his papers, chiefly on mineralogy and geology, published in the first ten volumes of this Journal. He gave also, during this period, an account of Bailey's new method of longitude, immediately on its appearance, in a manner which shows him to have been master of the subject.[1] From 1825 to 1845 he filled the chair of Chemistry and Natural History in Amherst College, with whose history and prosperity his name is inseparably connected. In 1845 he was chosen to the Presidency of Amherst, retaining the duties of instructor in geology and natural theology. In 1854 he resigned the presidency, having during his discharge of its duties conferred the most substantial benefits upon the institution, rescued it from a state of depression and insolvency to one of comparative abundance and substantial endowment, and doubled the number of attending students. He retained until his death his favorite duties of the geological chair, as well as those of natural theology.

In the history of the Governmental Geological Surveys, Prof. Hitchcock's name must always hold a prominent place. It was by his suggestion that, in 1830, the State of Massachusetts added a geological surveyor to the corps charged with the preparation of a trigonometrical survey of that State. His first report on the Economical Geology of the State was published in a pamphlet of 70 pages, in 1832, with a geological map. In 1833 he made a full report on the whole subject, in a volume of about 700 pages, with an atlas of plates and a geological map. In 1837, under the governorship of Mr. Everett, he was commissioned anew to re-examine the geology of the State, which resulted at last, in 1841, in a final report in two quarto volumes of 840 pages, with 56 plates and 82 wood-cuts. This was independent of the separate reports on zoology and botany made by the able naturalists who were associated with him. Several other reports followed, on Surface geology, on the Hematite of Berkshire, &c., and lastly the final report on the Ichnology of New England, the result of more than twenty years of study of an intensely interesting but difficult subject. This report was published by the State at an expense of about $5000. In 1856, when borne down by severe infirmity, he had still the courage to undertake, with his two sons, the geological survey of Vermont, which was brought to a successful issue notwithstanding that, as he says in his "Reminiscences," the Legislature "starved them out," the final report of about a thousand pages having appeared in 1862. His last paper, "New facts and conclusions respecting the Fossil Footmarks of the Connecticut Valley," was published in July of 1863, (our last volume, p. 46,) and we well remember the conviction he then expressed, that it was his last production—although it was so much his habit to despond and still labor on, that we felt it not unlikely we should again welcome his well known signature to our pages. Fortunately his strength held out for the completion of his "Reminiscences," the preface of which bears date Sept. 1st, 1863. In that personal narrative, while dealing primarily with Amherst College and his labors in her

[1] This Journal, vol. ix, p. 107.

behalf, we find a mirror of his scientific life and labors. How much he was the servant of all work, in his position of President, appears from the following passage:

"My epistolary correspondence in the Presidency was peculiarly onerous. I had previously been so much of a *jack at all trades* that I had laid myself open to inquiries and assaults from all classes. The same mail (and I hardly exaggerate the literal fact,) might bring inquiries about some point in the theory of temperance—how to employ garnet in making sand-paper—how to reconcile the imputation of Adam's sin with our sense of justice—where to find the best beds of sulphate of baryta—whether I would like to exchange or buy shells, minerals and fossils—how cheaply an indigent young man can go through the college and with what helps—whether I know of any one who will make a good teacher of a common school, an academy, or a professor in a college—or any one to supply a pulpit—what I think of a new theory of drift, or of latent heat—or new views of the relations of geology to Moses—or a new poem—or a new work—all of which are sent and an answer requested, if possible, by return mail."

We can do no justice to such a life as Prof. Hitchcock's in a brief notice. Earnest, simple, and sagacious, indefatigable under all discouragements, his clear, firm grasp of truth sustained and raised him above all difficulties, and has secured him an honored name in science. And this is not all, for science with him was ever made tributary to Christian truth and effort.

Plana.—Baron Giovanni Plana, the most renowned of Italian astronomers and mathematicians, died at Turin, on the 20th of January last, in his eighty-third year. Few men have left more enduring monuments of industry and power in the difficult branches to which he devoted his life, than Plana. The very last volume of the Transactions of the Turin Academy received here contain no less than seven elaborate memoirs from his pen. His theory of the moon is perhaps his most celebrated memoir. At the last session of the Turin Academy—the same which received the news of his death—a second paper was presented from him on the cooling of the heavenly bodies and an analytical expression of the sun's heat.

Heinrich Rose, the illustrious chemist, died at Berlin, on the 28th of January, at the age of 69 years, having filled the chair of Chemistry in the University of Berlin for more than forty years. He was a pupil of Berzelius, at Stockholm, in 1819. His treatise on Analytical Chemistry has been translated into French and English, and for a long time was almost our sole authority. *Poggendorff's Annalen* contained nearly all his papers, and scarcely a volume of that important journal for forty years past is without contributions from his pen. Rose was in private life one of the most gentle and excellent of men. Thus in two months has the University of Berlin lost two of her most illustrious men, Mitscherlich and H. Rose.

Cappocci—the learned director of the Observatory of Capodimonte (Naples), died on the 6th of January, of an affection of the heart, at the age of sixty-six years.

Notices of new publications received are necessarily deferred for want of space.